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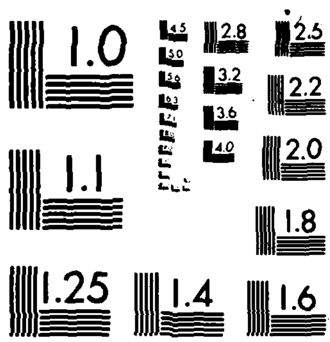

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TECHNICAL INFORMATION BULLETIN

83-3

CCITT STUDY GROUPS XI AND XVIII DRAFT RECOMMENDATIONS FOR ISDN NOVEMBER 8 - DECEMBER 2, 1983

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This Information Bulletin describes briefly the draft recommendations (standards) of the International Telegraph and Telephone Consultative Committee (CCITT) that were revised or prepared at a Novemebr 1983 meeting of the committee which dealt with Integrated Services Digital Networks (ISDNs). A list of special terms widely used in the recommendations and their meanings is included. The appendix contains the text of the recommendations as presented at the meeting.

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TECHNICAL INFORMATION BULLETIN 83-3

REPORT OF WORK ON DRAFT RECOMMENDATIONS FOR ISDNs AT THE INTERNATIONAL TELEGRAPH AND TELEPHONE CONSULTATIVE COMMITTEE STUDY GROUPS XI AND XVIII MEETINGS IN GENEVA, SWITZERLAND, FROM NOVEMBER 8 THROUGH DECEMBER 2, 1983

APPROVED FOR PUBLICATION:

Marshall L. Cain

MARSHALL L. CAIN
Assistant Manager
(Technology and Standards)
National Communications System

FOREWORD

The Office of the Manager, National Communications System, is assigned the management of the Federal Telecommunication Standards Program, which is an element of the overall General Services Administration's (GSA's) Federal Standardization Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee, identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems, or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards, a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the Electronic Industries Association, the American National Standards Institute, the International Organization for Standardization, and the International Telecommunication Union. This Technical Information Bulletin discusses the current status of certain CCITT draft recommendations relating to proposed Integrated Services Digital Networks (ISDNs). (The explanatory material on pages 1-20 of this TIB was written by Frank McClelland, Electronics Engineer; the TIB was compiled, edited, and published by Janet M. Orndorff, Editorial Assistant.) Comments or statements of requirements that would assist in the advancement of this work are welcome and should be addressed to:

Office of the Manager
National Communications System
ATTN: NCS-TS
Washington, DC 20305
Telephone--Commercial: (202) 692-2124
AUTOVON: 222-2124
FTS: 692-2124

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1. INTRODUCTION.

The purpose of this Technical Information Bulletin is to report to the FTSC (Federal Telecommunications Standards Committee) work done on the major CCITT (International Telegraph and Telephone Consultative Committee) recommendations on Integrated Services Digital Networks at meetings in November and December 1983. The first part of this TIB gives an overview of the 10 recommendations from these meetings while the appendix contains the text of the actual recommendations. The recommendations are in draft form and have not been approved by the complete study groups concerned, but will be used by some manufactures to start preliminary development of ISDN equipment. Also included in this TIB, as section 5, is a glossary of most of the commonly used ISDN terms. Figure 1, based on draft Recommendation I.411, which was not considered at these meetings, shows the interface points at the user's premises, for reference in reading other recommendations.

2. BACKGROUND.

The term Integrated Services Digital Network is used to describe a network having digital transmission and supporting most of the telecommunications services presently provided by separate dedicated networks, such as analog telephony, telex, and message switching. The practicality of incorporating all such services in a single network arises from the rapidly decreasing costs of both digital transmission and digital processors. As can be seen from examining the draft recommendations, such an approach is economically viable only if simple digital processors are very inexpensive, since even a digital telephone must include an amount of processing logic that would have been considered large ten years ago.

In spite of the giant technical steps that must be taken to design, develop, and implement ISDN equipment and networks, it is expected that the present telephone networks in most of the world will start evolving toward ISDNs within a few years--probably within three or four years. ISDN-like PABXs (private branch exchanges) will be available possibly within one or two years after the CCITT recommendations are approved at plenary meetings next year. The word "like" qualifies ISDN because many of the first products will not have all the characteristics and features that are desribed in the recommendations and that will ultimately become standard throughout the world. It is expected, however, that the first systems will have 64 kbit/s channels that can carry either digitally encoded speech or other data, out-of-band signalling by a separate channel that operates in a packet-switching mode, and possible other data channels. Until present 56 kbit/s transmission equipment in the U.S.A. is converted to 64 kbits/s, some equipment sold may operate at 56 kbit/s. (Most 56 kbit/s channels in the U.S.A. actually transmit 64 kbit/s, but 8 kbit/s are reserved for signalling and for insuring enough electrical transitions to maintain timing at repeater stations. A new digital encoding technique, called B8ZS and described in Recommendation G.703, will take care of the timing problem, and the signalling can be carried on the ISDN separate out-of-band signalling channel.)

Although not specifically related to the forthcoming ISDNs, a draft

recommendation, G.7zz (zz numbers to be assigned later), prepared at these meetings describes a 32 kbit/s adaptive differential pulse code modulation (ADPCM) voice encoding algorithm that may ultimately influence the way the ISDN 64 kbit/s channel is used, as, for example, being subdivided into two channels. The 32 kbit/s draft recommendation specifies the encoding from a A or mu law channel operating at 64 kbits/s to the new 32 kbit/s encoding. However, the first step in the encoder is to convert the A or mu law signal to a uniform PCM (pulse code modulated) signal, which could also be the input from a voice A/D (analog to digital) encoder. The 32 kbit/s algorithm is specified in such detail that it can be implemented unambiguously by several manufacturers without any change in quality of reproduction. For example, at each step, the accuracy of the digital conversion is specified in number of binary bits, their format (fixed or floating point), and the division of the bits between mantissa and characteristic, if floating point. This draft recommendation and an accompanying report from the developing committee will be distributed separately to members of the FTSC.

Recommendations for this CCITT Study Period (1981 - 1984) will be approved at plenary meetings in 1984 and published in bound volumes, which will be known as Red Books for the color of their covers. As a general rule, recommendations are not formally approved and published except at the end of study periods, so these recommendations will remain in force until 1988. In cases of urgency, it is possible to approve recommendations within a study period by means of expedited procedures, but this method is rarely used since it introduces too much uncertainty for manufacturers and implementers. Study Group XVIII ISDN Working Teams will meet again in February, in Brazil, to finalize their draft recommendations before they are presented to the Study Group XVIII plenary for approval, probably in May 1984. Working Group 6 of Study Group XI, which is developing the layer 2 and layer 3 protocols for the signalling channel, is not scheduled to meet until the Study Group XI plenary, also probably to be held in May 1984. Since Study Group XVIII has requested extensive changes in the current draft of the layer 3 protocol (Q.930), it is possible that an attempt will be made to schedule a meeting of a portion of Working Party XI/6 to deal only with Q.930 before that time. In any event, substantial extentions to and changes of the Study Period 1981 - 1984 recommendations should be expected in Study Period 1985 - 1988.

3. TYPES OF ISDN RECOMMENDATIONS.

CCITT recommdations are written in a style similar to standards, as, for example, those published by the American National Standards Institute. They are called recommendations rather than standards so that it is clear that their use is entirely up to individual countries and companies. (The CCITT is part of the International Telecommunications Union, an organization of the United Nations.) Although it is often said that CCITT recommendations need only address matters concerning interoperation between networks in different countries, it has been found practical with modern digital networks to specify also the customer-network interface. This allows equipment manufacturers to have product lines that are compatible with most national networks, allows users to transport equipment between networks, and helps in developing network internal protocols that require minimum format conversion at the

user-to-network interface. In fact, in the case of the widely-used Recommendation X.25, for packet-switching services, the customer-to-network interface was specified several years before the network-to-network interface was specified.

For convenience in discussing them, the ISDN recommendations included in this TIB can be considered as being grouped into three categories. The first group specifies what the ISDN is to do in terms of services that are visible to the user. The second group specifies the network architectural features on which the recommendations are based. The third group specifies the electrical characteristics and protocols that are to be used. The grouping is not precise in that some recommendations cannot be assigned exactly to one of the three groups, in which case arbitrary choices are made (for example, with the numbering plan), but it should aid the reader in sorting out the large amount of detail contained in the recommendations. A listing of the recommendations in each category follows at the end of this section.

One area of importance that is not included in this TIB is that of the protocols on the out-of-band signalling channels between network switches. It is expected that these signalling protocols will be from CCITT Signalling System Number 7 (present version specified in Recommendations Q.701 through Q.741), but there may be some different signalling messages developed to support the ISDN services. It is an objective to have the signalling messages on the user-to-network signalling channel match as closely as possible those of the ISDN part of Signalling System Number 7 to reduce protocol conversion processing at the terminating switches. The user-to-network protocols are described in draft Recommendation Q.930, which is discussed in detail in § 4.11.

The following ISDN draft recommendations are discussed in more detail in § 4 of this TIB and are reproduced in the appendix.

ISDN Draft Recommendations Relating to Services Offered the User.

I.200 Services Supported by an ISDN
I.2xx Bearer Services Supported by an ISDN
I.320 Addressing and Numbering Principles in ISDN
I.325 (I.3xx was designation before xx was replaced by 25) ISDN Connection Types

ISDN Draft Recommendations Relating to Architectural Models.

I.300 ISDN Network Functional Principles
I.310 ISDN Functional Architecture Model--Part A: Functional Model
I.311 ISDN Protocol Reference Model

ISDN Draft Recommendations Relating to Electrical Characteristics and Protocols at the User-to-Network Interface.

I.431 Basic User/Network Interface - Layer 1 Specifications
I.432 Primary Rate User/Network Interface - Layer 1 Specifications
Q.920 (I.441) Specification of the ISDN User-Network Interface Data Link Layer Protocol

Q.930 (I.451) Specification of the ISDN User-Network Interface Layer 3 Protocol

Note: Q designations are given by Study Group XI; I designations are those by which recommendation is known in Study Group XVIII.

4. BRIEF DESCRIPTIONS OF RECOMMENDATIONS.

In the following sections, a brief abstract will be given of the contents of each of the recommendations listed at the end of § 3. The purpose is to give the reader an overview of the type of material covered in each draft recommendation so that specific recommendations can be selected for more thorough study, if desired. Thus, these abstracts should be used as descriptions of the content only, and reference to the actual recommendations should be made for definitive, "official" specifications. The layers referenced in the descriptions are the layer in the Open Systems Interconnection architectural model developed by CCITT and by ISO. A particular protocol may overlap somewhat between layers, but, in general, the data link layer corresponds to layer 2 and the network layer to layer 3.

4.1. I.200--Services Supported by an ISDN. (Revised at November 1983 Meeting of Working Teams 2, 3, and 4 of Study Group XVIII.)

Draft Recommendation I.200 describes the types of services offered by an ISDN, rather than the services themselves. Although the recommendation does not supply much information to the user about what specific services he can obtain from an ISDN, it does establish principles that will allow other more specific recommendations to establish boundaries between services so that they can be provided by different entities, such as private packet switching networks. A fundamental feature of ISDNs is that a few connection types can support a variety of services.

There are two general types of services offered by an ISDN, bearer services and teleservices. Bearer services are the basic connection services between users or between a user and a supplier of a higher service, such as a packet switch external to the ISDN. In Recommendation I.200, bearer services are discussed in terms of layers of the Open System Interconnection model, specified in Recommendation X.200 (of Study Group VII, not an ISDN recommendation). These layers are discussed in more detail in §4.5, below. Bearer services utilize only the physical layer functions, and possible the data link and network layer functions. A bearer service is composed of a basic bearer service and possibly optional supplementary bearer services. A bearer service offered by a particular provider, such as a local operating company, will include functions from the first three OSI (Open Systems Interconnection) layers, but may not include all of the functions possible. The additional functions are called ALFs (additional lower layer functions) and can be offered by other providers or by the terminal itself.

More elaborate services, as, for example, telex service, involve higher layers of the OSI model and are called teleservices, which were referred to as telecommunication services in previous drafts of ISDN recommendations. It is in this category that decisions on definitions become difficult because of the

conflicting interests between groups that want to provide for competitive offerings of such services (in the U.S.A., for example) and groups that do not want to encourage offering these services by providers outside the national telecommunication network. Decisions are also complicated by the desire of some telecommunication offers to charge different tariffs for the same connections when used for different services.

4.2. I.2xx--Bearer Services Supported by an ISDN. (Revised at November 1983 Meeting of Working Teams 2, 3, and 4 of Study Group XVIII.)

The following types of bearer services are listed in the current draft of I.2xx.

- circuit 64 kbit/s unrestricted (transparent bit stream)
- circuit 64 kbit/s, speech information transfer (A and mu law encoding)
- circuit 64 kbit/s, voice band (approximately 3.2 khz, unrestricted as to content)
- 384 kbit/s leased-circuit
- 1536 kbit/s switched
- 1920 kbit/s switched
- packet mode virtual circuits
- connectionless packet service on a D channel

4.3. I.320--Addressing and Numbering Principles in ISDN. (Revised at November 1983 Meeting of Working Teams 2, 3, and 4 of Study Group XVIII.)

Three fundamental issues have plagued the development of an ISDN numbering plan. First, the plan needs to be compatible with present numbering plans so that in the transition period to the fully ISDN era existing numbering plans are usable. Second, the ISDN plan needs to be able to accommodate within one plan the diverse services of ISDNs. Third, some feel that provision needs to be made for addressing and specifying private and dedicated networks, while others do not want to cater for non-national ISDN networks.

The actual IDSN numbering plan will be specified in Recommendation E.16n, not yet prepared, which is the responsibility of Study Group II. (The digit n has not been selected.) Until E.16n is available, I.320 will contain more details than will be perhaps in the final version.

The structure of the ISDN address in the present draft of I.320 contains four elements; country code, trunk code, ISDN subscriber number, and ISDN sub-address. These are further grouped as follows.

- ISDN address
  - International ISDN number
    - Country code
    - National ISDN number
      - Trunk code and/or destination network identification
      - ISDN subscriber number
  - ISDN sub-address

The country, or geographic area, codes will be the codes presently specified in Recommendation I.632. Although not specified by I.320, it was felt that the international ISDN number need not be longer than 15 decimal digits. The maximum lenght of the subaddress, which is optional, is specified to be 32 decimal digits.

An important principle stated in the draft recommendation is that provision will be made for specifying destination and transit networks (e.g., MCI) when permitted by national regulations and these networks will be considered when the connection is routed. The transit network would not be identified by the ISDN number, however, but would be identified by other elements in the signalling message. (An example of an implication would be that if a user specifies a particular routing network in, say the U.S.A., and multiple gateways are available from the user to the U.S.A., the national gateway closest to an MCI interconnection point would be chosen.) Another significant principle is that mobile users area to be addresses the same as a stationary users. Direct dialing in (DDI) is to be supported.

4.4. I.325--ISDN Connection Types. (Revised at November 1983 Meeting of Working Teams 2, 3, and 4 of Study Group XVIII.) (I.3xx was previous designation.)

The following families of ISDN connection types are listed in draft I.325.

- o 64 kbit/s, circuit switched, transparent
- o 64 kbit/s, circuit switched, non-transparent
- o 64 kbit/s, permanent, non-switched, transparent
- o 64 kbit/s, permanent, non-switched, non-transparent
- o 384 kbit/s, permanent, non-switched, transparent
- o 384 kbit/s, permanent, non-switched, non-transparent
- o Packet--virtual circuit, switched, transparent
- o Packet--virtual circuit, permanent, non-switched, transparent
- o Packet--connectionless, established via a D-channel

An ISDN connection is effected by one or more connection elements, arranged in tandem, parallel, or point-to-multipoint so that the overall end-to-end connection has the required characteristics. The various elements can be established and released simultaneously (called a sequential configuration) or may be established and released separately (called an add/remove configuration).

I.325 lists 11 possible connection element attributes, but describes the following four as the major ones.

- o Mode of connection (circuit switched; packet switched)
- o Establishment of connection at level 1 (demand; reserved; permanent)
- o Throughput, bit rate (bit rate; other types, to be defined)
- o Transparency (transparent; non-transparent; others)

4.5. I.300--ISDN Network Functional Principles. (Revised at November 1983 Meeting of Working Teams 2, 3, and 4 of Study Group XVIII.)

The stated purpose of I.300 is to be an overview and introduction of the network series of recommendations. This series of recommendations, in general, describes the principles of what is to be done rather than technical details of how it is to be done. The principles discussed are often ultimate objectives rather than immediate requirements.

Recommendation X.200, developed by Study Group VII, describes modern open system network architecture from the CCITT viewpoint. Open system means, broadly, that connection to the system is open to all terminals. achieve this objective, various functions needed to transport data betwe two or more users are grouped into related categories, called layers. The l rs are numbered from 1 to 7 and are structured such that a layer relies the previous lower numbered layer to supply services to it so that an supply other services to the next higher numbered layer. The following e is a rearrangement of figure 4 in draft recommendation I.300, and has ed the names by which the layers are commonly known. Since nomenclature used by ISDN, such as network, may not correspond exactly to X.200 definitions at present, Study Groups XI and XVIII often avoid specifing a layer by its name.

- Layer 7 (Application Layer)
  - Application related functions
- Layer 6 (Presentation Layer)
  - Encryption/decryption
  - Compression/expansion
- Layer 5 (Session Layer)
  - Session connection establishment
  - Session connection release
  - Session connection synchronization
  - Session to transport connection mapping
  - Session management
- Layer 4 (Transport Layer)
  - Layer 4 connection multiplexing
  - Layer 4 connection establishment
  - Layer 4 connection release
  - Error detection/recovery
  - Flow control
  - Segmenting/blocking
- Layer 3 (Network Layer)
  - Routing/relaying
  - Network connection establishment
  - Network connecton release
  - Network connection multiplexing
  - Congestion control
  - Addressing
- Layer 2 (Data Link Layer)
  - Data link connection establishment
  - Data link connection lease

Flow control
Error control
Sequence control
Framing/synchronization

Layer 1 (Physical Layer)

Physical layer connection activation
Physical layer connection de-activation
Bit transmission
Channel structure multiplex

Draft I.300 proposes that the end to end connection be considered to be composed of a series of connection elements. When the user initiates a service request, a set of attributes, such as throughput and maximum delay allowed, would be specified. Based on the attributes, an appropriate overall connection type would be determined, such as 64 kbit/s circuit switched, transparent. (Transparent implies that no compression of data is allowed. 64 kbit/s voice, on the other hand, could be converted to 32 kbit/s voice on route, as long as it was converted back to 64 kbits/ at the other end.) A listing of ISDN connection types is in table 1 of draft Recommendation I.325. Between different modes, different connection elements could be used, as long as they would allow overall end-to-end characteristics as specified. For example, a 384 kbit/s element could be used. Draft Recommendation I.325 contains a list of ISDN connection types in table 1 and a list of connection elements in figure 6.

4.6. I.310--ISDN Functional Architecture Model--Part A: Functional Model. (Revised at November 1983 Meeting of Working Teams 2, 3, and 4 of Study Group XVIII.)

The stated purpose of I.310, part A, is to provide a functional description of ISDN capabilities. Part B, which in the present draft is referred to as containing architectural descriptions, has not been included. In previous drafts, part B contained conceptual examples of connections between various ISDN, specialized (e.g., X.25), and private networks along with some politically sensitive diagrams showing interfaces between the line terminations at the central office switch and the switch.

Draft I.310 introduces the concept of lower layer functions (LLF) and higher layer functions (HLF), where the lower layers are layers 1, 2, and 3 of the open system model while the higher layers are layers 4, 5, 6, and 7. The lower layer functions are subdivided into bearer functions (BF) and additional lower layer functions (ALLF). Bearer function functions are the basic functions needed to transport data between users, while ALLF are other lower level services, not explicitly defined at this time. The finalization of definitions of BF, ALLF, and HLF has been delayed because the implication they may have on economic and regulatory factors, such as the prohibition of some telecommunication providers to furnish higher layer functions in a regulated environment (e.g., the FCC computer inquiry in the U.S.A.). Draft I.310 repeats the table of functions in each architectural layer and the connection element diagrams from I.300. Draft I.2xx (see §4.2) discusses bearer service attributes.

4.7 I.311--ISDN Protocol Reference Model. (Revised at November 1983 Meeting of Working Teams 2, 3, and 4 of Study Group XVIII.)

This draft recommendation contains many two and three dimensional figures showing how the various architectural layers are related in connections through circuit and packet switches between users. The figures use a concept, not yet accepted by all open system architecture experts, of separate control and user planes in the architectural models. That is, network control, end-to-end, may flow through all seven layers as does user data. (The alternative approach is to consider that layer three in the connection containing the user data connects functionally with other application programs, which may have seven layers, at the network nodes.)

4.8. Draft I.431--Basic User/Network Interface - Layer 1 Specifications. (Revised at November 1983 Meeting of Working Teams 2, 3, and 4 of Study Group XVIII.)

In order to allow development of ISDN protocol modules that have well-defined inter-module boundaries, the recommendations follow the Open System Interconnection Reference Model layers. Recommendation I.431 has layer 1 specification in its title, but it actually contains more than layer 1 specifications. Layer 1 of the Open System Interconnection Reference Model is usually considered to be transmission media independent; that is, it does not describe the media physical characteristics, but only its functional characteristics. However, draft Recommendation I.431 gives detailed specifications for the electrical characteristics of the generators and receivers, in addition to specifications of layer I functional procedures. "Basic" in the title refers to a specific type of interface; namely, the interface that has two B channels at 64 kbit/s each and a D channel at 16 kbit/s.

Recommendation I.431 can be broadly dividied into four sections: (1) configuration of distribution wiring at the user's premises, (2) electrical characteristics of generators and receivers, (3) operating power requirements and connections for ISDN portion of terminals, (4) procedures for activating and deactivating the digital link, and (5) format of the frame of bits representing the B and D channels. Each of these sections will be summarized briefly in the following paragraphs.

4.8.1 Two wire pairs are needed to connect ISDN terminals, one for transmitting and one for receiving. Due primarily to the insistence by the European members of CCITT, the ISDN basic interface has been designed to allow connection of parallel terminals at the user's premises, much as parallel telephone extensions can be connected in the present analog networks. This is called a passive bus arrangement since no active elements are between the network termination and terminals. Because the ISDN interface is digital and operates at the fairly high rate of 192 kbit/s, connection of parallel terminals must be done much more carefully than is required for existing telephones. Three configurations are discussed in I.431. In a point-to-point configuration allowing only one terminal or telephone on the line, as might be

the case when connected to a PABX, the distance of the connecting wiring can be up to 1000 meters. When up to 8 termi.als are connected in parallel, the total length of the connecting bus can be up to 150 meters and the lengths of the stubs connecting the terminals to the bus should not exceed 10 meters. In an extended bus arrangement in which distances between connection of individual terminals is limited to 35 meters, the total length of the bus can be about 500 meters. The worst possible configuration, insofar as reflections and delays are concerned, is for one terminal to be connected near the network termination and the rest connected in a cluster at the other end of the bus.

It should be noticed by system implementers that simple active elements that repeat the digital and signal, and, perhaps, adjust timing offset, can eliminate many of the electrical deficiencies of the passive bus and extend its permitted length. While an active bus configuration is illustrated in I.431, no specifications concerning it are given.

4.8.2 Detailed voltage pulse specifications are given in the form of pulse shape masks. The nominal output voltage is 750 mv. The terminal transmitter output impedance and receiver imput impedance are functions of frequency, but are about 2,500 ohms in the 20 khz to 80 khz range.

Electromagnetic interference radiation from ISDN wiring is apt to be fairly significant unless the system is carefully balanced around ground and the voltages are kept low. It has been agreed that shielded wiring should not be necessary, but in special situations it should be considered. The standard ISDN connector for the basic interface will be the eight-circuit modular plug now used on A.T.&T. equipment.

4.8.3 There will probably be more than one way of supplying power to ISDN terminals since terminal types will vary from digital telephones to large computers. Because of difficulty in transmitting power over optical fibers from central offices and because of the desire to simplify the network termination at the user's premises, it is possible that central office power will not be supplied to terminals, even digital telephones, in the U.S. There are two specified ways of supplying power to terminals, over a phantom arrangement of the transmitting and receiving circuits and over two separate connectors. The power on the phantom may be from the network or from a power supply connected to the local a.c. source. The amount of this power in normal operating conditions is not specified in ISDN recommendations. Under emergency situations, as when the local a.c. source fails, the power on the phantom will be at least 400 mW, if supplied, and will be reversed in polarity to indicate that a limited power condition exists. The d.c. voltage of the supply will be either 24 volts or 40 volts. When a terminal is powered down (that is, inactive) it must not consume more than X watts, where X will probably be between 0 and 50 mW.

4.8.4 Proper activation and deactivation of a terminal as it is powered up or down or connected or disconnected from a bus is rather complicated because it must not disturb any other terminal that might be active. Additionally, it must ultimately synchronize to a framing sequence that accommodates the two B channels, the D channel, and spare bits. Basically, a terminal when first

connected listens to the receiving side of the bus. Three signals are possible: no signal (called INFO 0), alternating positive and negative pulses (called INFO 2) and normal operational data (called INFO 4). In general, INFO 2 indicates that an attempt is being made by the network termination to activate the bus. If the terminal deduces from INFO 0 that the bus is active, it transmits framing pulses but sets all data bits to logical 1 (zero voltage level) to indicate that it would like for the bus to be activated.

4.8.5 The proposed frame structure for the basic ISDN access interface has 48 bits and is transmitted in 250 microseconds, which equates to a bit rate of 192 kbit/s. The technique is called pseudo ternary, which means, here, that logical 1s are transmitted as zero volts and logical 0s are transmitted as alternating positive and negative pulses of about .75 volts amplitude. Framing boundaries are indicated by points at which the alternating positive and negative pulse rule is violated. That is, framing pulses are logical 0s that are transmitted with the same polarity as the preceding logical 0; the preceding logical 0 may not occur in the preceding bit position, so the framing mechnism must remember the polarity of each logical 0 until the next is received. Each group of bits that might be transmitted from one terminal, such as eight B channel bits, is followed by a balancing bit, called an L bit, that insures that the d.c. balance is restored to the bus. Since logical 0s are alternating pulses, there can never be more than one bit out of balance before the L bit.

Contention resolution between two or more terminals trying to access the bus at once is reconciled at two levels. At the higher level, a terminal does not transmit on either of the B (64 kbit/s) channels without receiving permission to do so on the D (16 kbit/s) channel. At the lower level, contention on the D channel is resolved electrically. Each D channel bit from terminals to the network termination (NT) is echoed by by the NT as an E bit. As seen by the NT, the D channel bits are controlled by the terminals attempting to raise the D bit from the zero voltage level. For example, if two terminals a transmitting a D bit simultaneously and one transmits a zero voltage (1 bit) while the other transmits a positive voltage (0 bit), the NT would see a positive voltage and echo a 0 bit. The convention is that a terminal that sees a E bit that is not the same as the corresponsing D bit it transmitted should cease transmission, thereby resolving the contention.

4.9. Draft I.432--Primary Rate User/Network Interface - Layer 1 Specifications. (Revised at November 1983 Meeting of Working Teams 2, 3, and 4 of Study Group XVIII.)

The primary rate ISDN interface will operate at 1544 kbit/s or at 2048 kbit/s to conform with existing digital transmission equipment, the lower rate being used primarily in the U.S.A. One use of the primary rate interface might be to connect PABXs to ISDNs. The interface will accommodate 23 B channels and a D channel at the lower rate or 30 B channels and a D channel at the higher rate. Alternately, groups of six B channels can be replaced by H_0 channels operating at 384 kbit/s. For the 1544 kbit/s interface, all B channels and the D channel can be replaced by an H_1 channel operating at 1536 kbit/s; for the 2048 kbit/s interface, all B channels can be replaced by an H_1 channel operating at 1920 kbit/s.

The basic electrical characteristics of the interfaces are specified in Recommendation G.703 which recommends electrical characteristics, bit rates, pulse shape, impedance, and code. Section 2 applies to the 1544 kbit/s interface while section 6 corresponds to the 2048 kbit/s interface. The D channel of the primary rate interface operates at 64 kbit/s instead of the 16 kbit/s rate of the basic rate interface. The protocol of the D channel can be either that defined in ISDN Recommendation Q.930 or it can be that of the Signalling System Number 7 protocol in Recommendations Q.701 through Q.741, in which case it is referred to as an E channel.

4.10. Draft Recommendation Q.920 (I.441)--Specification of the ISDN User-Network Interface Data Link Layer Protocol. (Issue 6, November 1983.)

This recommendation specifies a data link layer protocol that will be used on the out-of-band signalling channel, called the D channel, in IDSN networks between the user terminals and the network. The data link layer protocol in Q.920 is basically the protocol described as LAPB in Recommendation X.25 and as Asychronous Balanced mode of operation in International Standard IS-4335, published by the International Organization for Standardization, and in American National Standard X3.66, published by the American National Standards Institute. There is a fundamental difference, however, in that Q.920 has incorporated an address field that permits the NT (network termination) to communicate with several terminals connected in parallel whereas the other three standards restrict the balanced mode to operate between two points only. Q.920 uses a two-octet address field according to the standard extension rules of IS-4335 and ANS X3.66, but not incorporated in LAPB. Q.920 also has the UI (Unnumbered Information) frame, which is not included in LAPB. In addition, Q.920 contains, for clarification, much descriptive material on states assumed by the data link layer protocol processors and on primitives passed to and from the data link layer and other protocol layers.

Another fundamental difference is that Q.920 describes also a Single Frame Operation which makes use of a new frame, not yet considered or approved by other standards organziations. This new frame is called a TBN (To Be Named) frame and functions much as a UI frame would if the P/F (poll/final) bit in the UI frame is replaced by a modulo 2 sequence counter. (See §5.5 in Q.920.) No other commands or responses are used in the Single Frame Operation mode.

The certainty of the future continuing specification of the TBN frame will be determined after more thorough analysis of its operation, both in CCITT and in other standards organizations. It was introduced in order to have a simple protocol in which the NT and a terminal could exchange frames alternately. Possible other ways of doing the same thing are limiting the number of outstanding I (information) frames to one or using a standard UI frame exchange and tolerating the occasional loss of a frame.

The other major difference between Q.920 and similar data link layer standards is that Q.920 describes in detail how the contents of the address field is determined, using layer 3 messages. (See §1.3.4.3, §3.2, §3.3, and §5.3 in

Q.920.) This is necessary in ISDN systems because several terminals may be connected in parallel and can be moved by the user to other locations. The central office needs to have some way of identifying, at layer 2, a particular terminal so that it can send messages to it and not to all terminals in parallel. The way this is done in ISDN is for the terminal to request from the switch that a particular TEI (terminal endpoint identifier) be assigned to it. The procedure then checks to see if the same TEI is being used by another terminal connected to the same parallel bus. If it is, another TEI must be selected. Provision is also made for terminals that have a particular set TEI, as, for example, a TEI incorporated in the protocol integrated circuit chip. These terminals, however, may lack the flexibility of movement of those with an automatic TEI assignment.

The complete data link layer address consists of TEI and a SAPI (service access point identifier). Usually, a terminal has only one TEI, but may have several SAPIs to identify several processes within the terminal, each of which, in theory, could operate over a separate connection within the ISDN. The SAPIs can be assigned independently by the terminal, since the TEI portion of the address will be unique to that terminal.

Q.920 assigns bits 3 through 8 of the first octet of the data link layer address field to the SAPI and bits 2 through 8 of the second octet to the TEI. Of the 64 possible SAPIs, value 0 is specified for circuit-switched procedures, value 16 for packet-switched procedures, and value 63 for network management procedures. The 127 possible TEI values are divided into three groups, values 0 through 63 for non-automatic TEI assignment equipment, values 64 through 126 for automatiac assignment user equipment, and value 127 for the group address (all stations).

4.11. Draft Recommendation Q.930 (I.451)--Specification of the ISDN User-Network Interface Layer 3 Protocol. (Revised at November 1983 Meeting of Working Party XI/6.)

The information fields of the frames specified in Q.920 contain two general types of messages, specified by Q.930. The first type are messages that directly control the establishment of connections for the B (64 kbit/s) channels. This type is similar in function, then, to the on-hook, off-hook, and dial pulse signals sent from a standard analog telephone. The other type are messages that may contain user data and may be switched by packet handling facilities within the ISDN. (According to present draft recommendations, packet handling facilities outside the ISDN must be connected through the B channel.) To distinguish between the types of messages, the first octet in the information field contains a protocol discriminator, which, when set to value 8, indicates that the message is a Q.930 user-to-network call control message. Use of other values is reserved for future standardization, with values 16 through 63 and 80 through 1022 designated as "reserved for other network layer protocols, including X.25."

There are two categories of user-to-network call control procedures, called functional signalling and stimulus signalling. Functional signalling is usually the most efficient mode of signalling if the terminal has some

intelligence, but requires that the terminal remember which of the 20 presently defined states it is in and generate and interpret sometimes relatively complex messages as it interacts with the network. Stimulus signalling, on the other hand, requires that the terminal remember only two states (on-hook or off-hook, and receiving an alerting signal or not), but may lack flexibility in simultaneous use of more than one B channel. Stimulus signalling procedures are designed so that an operator can supply the logic to establish and disconnect calls, similar to operation of the analog telephone today. Functional signalling procedures take advantage of the intelligence of processors to perform these steps automatically. Of course, a processor could be programmed to automatically perform the steps in a stimulus signalling procedure as if it were the operator.

As an example of the difference in the functional signalling, the call set-up message sent when a stimulus terminal goes off-hook would usually contain only a call reference (a number that identifies a particular call to both the terminal and network), an indication of what type of call is being initiated (such as a 64 kbit/s encoded voice call), and, optionally an indication hat the terminal is off-hook. The dial signals would be sent in subsequent messages, either one at a time (overlap sending) or all together (en bloc) if the terminal could store the numbers until all were keyed in. The call set-up message from a function terminal would usually contain those sent by a stimumus terminal plus the called number and additional elements to indicate other desired features, such as remote charging and request for cost of call after completion.

The stimulus signalling procedures have been introduced in CCITT recently, supported primarily by A.T.&T. and its derivative companies. There is considerable debate within CCITT as to whether these simplified procedures will allow manufacturer of a cheaper terminal in the long run. The fact that stimulus signalling procedures may not be standardized worldwide and that certain switches may support only either stimulus or functional signalling could affect a manufacturer's ability to have only one worldwide product line and a user's ability to move terminals between geographic locations. A stimulus terminal should be more easily adapable to new operational features, however, since the programming change would be in the operator's mind rather than in the equipment firmware. (For a discussion of the economic implications of stimulus and functional signalling and how they might impact profits of network operators and terminal manufacturers, see the "Future Phone" article on the front page of The Wall Street Journal, December 23, 1983.)

5. SOME COMMONLY USED ISDN TERMS.

Following is a list of some of the abbreviations, acronyms, and special terms used in this report. This list, prepared by NCS, is not meant to define precisely the items, but should be helpful to the reader who wants a quick indication of the general meaning of the listed term. Some of the descriptions reflect decisions made at CCITT working party meetings which may be modified at subsequent meetings.

A/B interface--
telephone type nomenclature for the ring/tip, two wire, interface.

ALLF--
additional lower layer functions; refers to services that might be outside

the basic functions performed by the network in providing a connection, but still not related to the higher (e.g., 5, 6, 7) layers of the architectural model.

Alpha service--
used to describe network services lying between the basic connection service (bearer service) and telecommunications services that provide additional features, such as terminal compatibility checking; term may not be used in the future.

B channel--
a switchable, optionally transparent, 64 kbit/s channel; two such channels are included in the basic access service.

Basic rate--
an ISDN access rate of 192 kbit/s (2 B channels and a D channel)

Bearer service--
basic connection service, with out of band signalling (e.g., signalling on the D channel).

C channel--
a channel operating at 2, 4, 8, or 16 kbit/s and associated with analog voice transmission, rather than with B channels; this channel performs some of the functions of a D channel; not presently being pushed in CCITT.

CN--
connection.

Compelled--
a mode of operation at layer 2 (link layer) that uses non-sequenced information frames with only one unacknowledged frame allowed to be outstanding; acknowledgement effected through poll and final bit exchanges; similar in operation to "ACK-NAC" protocols, except "NAC" is implicit rather than explicit; also referred to as "simplified protocol".

CRF--
connection-related functions.

CT--
connection type; basic characteristic of a connection; e.g., 64 kbit/s, circuit switched, transparent; described in Recommendation I.325.

Connection element--
a component of a connection type.

D channel--
a channel whose primary purpose is to convey signalling information between a terminal and the network switch, but whose surplus capacity can be used for user packet data and other data, such as telemetry; it operates at 16 kbit/s for basic access and at 64 kbit/s for primary access rates.

DSL--
digital subscriber loop.

E bit--
bit that echoes, in the network to terminal (NT to TE) direction, D channel bit in the TE to NT direction; used in contention resolution procedures when more than one terminal attempts to use the D channel at the same time. (Notice that the E bits are not the bits used by the E channel.)

E channel--
a channel operating at 64 kbit/s and using CCITT signalling system number 7 protocols; it may supplement or be used in place of a D channel for connections of private branch exchanges. (The E channel will likely use D channel bit positions or, perhaps, other yet to be defined bit positions.)

EMI--
electromagnetic interference; refers to possible radiation from leads connecting ISDN equipment.

ET--
exchange termination; the termination at the central office immediately before the switching stages; connects to V reference point on the customer side.

F bit--
framing bit in the access frame structure

FA bit--
auxiliary framing bit; used to ensure proper framing if no user data is present or if polarity of connecting leads is reversed; FA/S indicates that bit can be used as spare bit in some frames.

FF--
fixed format; refers to a fixed structure for inserting lower bit rates into a higher bit rate channel (rate adapting); contrasts to VF.

HO channel--
a channel operating at 384 kbit/s; presently specified for leased circuits only; can be used for high fidelity music.

H1 channel--
a channel at a higher rate than HO; 1536 kbit/s and 1920 kbit/s are under consideration.

HLF--
higher layer functions; refers to services performing functions related to the "higher" layers (e.g., 5, 6, 7) in the architectural models; examples might be data base related functions.

HRX--

hypothetical reference connection; a model of worst case connections that is used to study the various technical and operational aspects of the ISDN; connection may not be actual worst case, but may represent typical worst case.

ISDN--

Integrated Services Digital Networks; characterized by supporting both voice (digitized) and data transmission.

L bit--

dc balancing bit in the frame structure; needed because coupling transformers cannot pass dc.

LT--

line termination, at the switch end of the subscriber connection.

NT2--

network termination type 2; private branch exchanges and local area network controllers are examples of NT2s.

P_A--

minimum power available to terminal when power is fed by phantom arrangement over signalling leads and power from local ac source is not available; present draft suggests that it should be 400 mW, but may be reduced to 250 mW in the next study period; this may be only power in case of emergency conditions. Also called P alpha.

P_B--

maximum power extracted by the terminal in emergency or local ac power loss situations from the phantom arrangement over the signalling leads; current draft does not use P_B but indicates a maximum available current will be specified. Also called P beta.

P_G--

minimum power available to terminal when power is fed by phantom arrangement over signalling leads and power from local ac source is available; present draft says that its value will be up to individual administrations (operating companies).

P_N--

maximum power extracted by the terminal in normal operation when power is fed by phantom arrangement over signalling leads; not used in current draft.

PABX--

private automatic branch exchange.

PH--

packet handling; usually used to refer to such a service in an ISDN.

Primary rate--
an ISDN access rate of either 1544 kbit/s (23 B channels and a D channel) or 2048 kbit/s (30 B channels and a D channel).

S Information--
signalling information; used with S-plane information in discussing architectural model.

S bit--
space bit in the frame structure; may be used in the furure for activation-deactivation procedures and maintenance.

S interface--
a reference point on the customer side of NT2; as an example, the interface to which a digital telephone could connect to a private branch exchange.

T interface--
a reference point on the customer side of NT1; as an example, the interface to which a digital telephone could connect (for 192 kbit/s interface) or to which a local area network gateway controller could connect; the bit rate may be either 192 kbit/s for basic access or 1544 or 2048 kbit/s for primary access.

TE1--
terminal equipment type 1; standard ISDN terminal that can be connected to the S or T (192 kbit/s) interface.

TEI--
terminal endpoint identifier; a link level identifier (number) that is necessary for the terminal to communicate over the D channel with the switch or NT; this may be variable or fixed (see page A.025).

Teleservice--
a telecommunications service that includes functions above the basic connection service; an example might be Telex.

TR--
termination resistance; a resistance used to prevent electrical reflections on ISDN connections; specified value is 100 ohms, $\pm$ 5 per cent.

Type A--
a service access point that supports a layer 2 (link layer) protocol that is simpler than the full ISDN protocol, Type B; current position is that all switches should support both Type A and Type B, but simplier terminals may use only Type A.

Type B--
a service access point that supports the full ISDN layer 2 (link layer) protocol; see also Type A.

Type C--

a service access point that has multiple layer 2 links, for redundancy and reliability; not expected to be included in recommendations of this study period (1981-1984), but will be studied in the next study period.

U Information--

user information; used with U-plane information in discussing architectural model.

U--

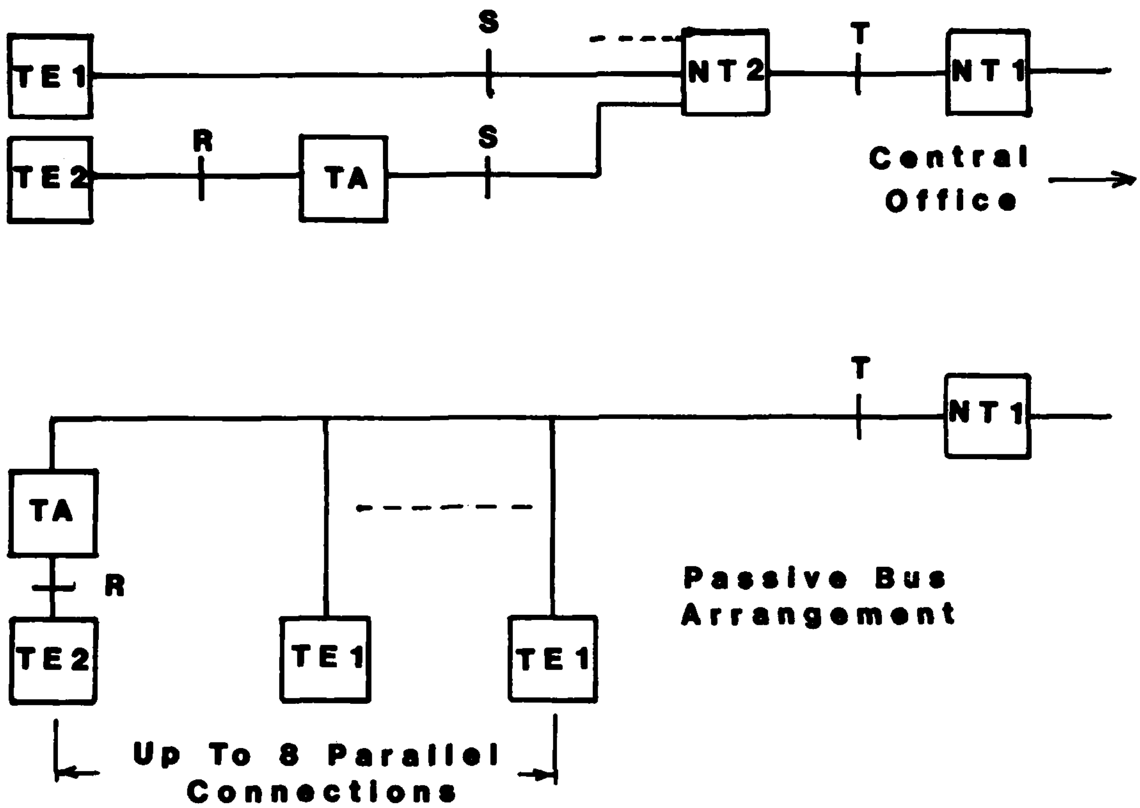
a reference point at each end of the connection between the subscriber and the local switch; NT1 connects to U at the subscriber end and LT connects at the switch end; characteristics unlikely to be standardized by CCITT.

VF--

variable format; refers to a variable structure for inserting lower bit rates into a higher bit rate channel (rate adapting); contrasts to FF (see page A.011).

V--

a reference point between the LT and ET.



R, S, T - Reference Points

NT1 - Network Termination, Type 1

NT2 - Network Termination, Type 2 (e.g., PABX)

TA - Terminal Adaptor

TE1 - Terminal Equipment, Type 1

TE2 - Terminal Equipment, Type 2

Note: If allowed by local regulations, any of NT1, NT2, TA, TE1, and TE2 may be combined in same physical unit.

Figure 1 - Examples of ISDN Interface Reference Points at User's Premises

APPENDIX

NOTE: This appendix contains ten draft recommendations that were produced at the November-December meetings of Study Groups XI and XVIII. These are reproduced in the same form as distributed at the meeting, except some pages that were not easily readable in the original have been retyped.

Page

CCITT

Temporary Document 43-E

STUDY GROUP XVIII

Geneva, 21 November-2 December 1983

Question 1/XVIII, p.A

SOURCE: WORKING TEAM 4

TITLE: ANNEX 2 TO THE REPORT OF WORKING TEAM 4 - DRAFT RECOMMENDATION I.200 - SERVICES SUPPORTED BY AN ISDN

Considering

- the ISDN concept described in Recommendation I.120;

- the ISDN functional architecture model described in draft Recommendation I.310; not available this study period. I.300 give principles.

- the ISDN protocol reference model described in draft Recommendation I.311;

- the ISDN connection types described in draft Recommendation I.325;

= the ISDN user network interface reference configurations described in draft Recommendation I.411;

- the ISDN service characterization described in draft Recommendations I.2xx and I.2xy; (Does not exist at present.)

and ISDN will support a wide variety of services. The purpose of this Recommendation is to provide a clarification and a method of description of such services to be used as a basis for defining the network capabilities required by ISDN.

1. Service concept

In the context of this Recommendation a service is a set of capabilities for communication which is defined by standardized protocols and functions.

Realization of the capability for communication according to a service requires a combination of network and terminal functions. The service classification and descriptions in the following are independent of different possibilities for ownership and form of provision (to the customer) of the means required to support a service.

A service provision by the network provider to a customer connected to an ISDN may cover the whole or only part of the means required to fully support the service. The operational and commercial features associated with the service provision are included in the service concept.

In the following, services are described by attributes that define service characteristics as they apply at a given reference point, e.g. S/T for bearer services, see section 3.

A supplementary service is used to modify or supplement a service. It cannot be offered to a subscriber as a stand alone entity. It must be offered together with or in association with main services. The same supplementary attributes; the supplementary low layer and high layer attributes. The concept of ISDN supplementary service corresponds to the concept of user facility in the X-series of Recommendations.

The concept of service classification is illustrated in Table 1/I.200.

TABLE 1/I.200

Telecommunication service classification

```
            Telecommunication Service
                      |
                 Bearer Service
                   |
                 Basic
               ____|__________
                |             |
                Supplementary |
                              |
                         Teleservice
                            |
                          Basic
                              |
                              Supplementary
```

2. Elements to support a service

2.1 The elements required to fully support a service for a customer connected to an ISDN include:

- network functions
- possibly terminal functions
- operational and commercial (i.e. sales or marketing aspects) features associated with the service provision.

Network functions are specified by Recommendation I.3....

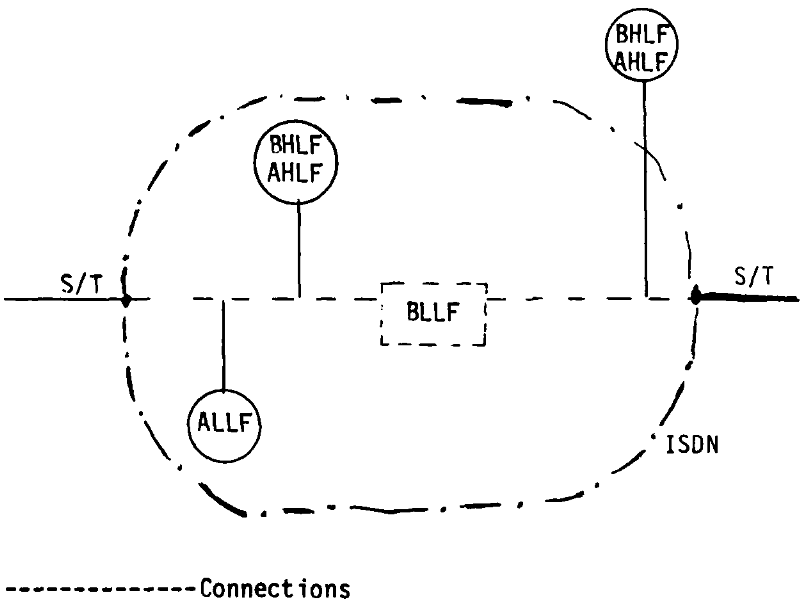
2.2 To support services an ISDN depending on national regulations, provides the following network functions whose definition appears in Recommendation I.310:

I.300 - Principles
I.325 - Connection Types

- Connections with the Basic Low Layer Functions (BLLF) and optional Additional Low Layer Functions (ALLF).

Depending on the category of service (see para 3) it may also provide, when permitted.

- Basic High Layer functions (BHLF) and optional.
- Additional High Layer Functions (AHLF).



Note - In certain national situations some type of sophisticated bearer services could also be provided by cooperation of an ISDN and a specialized network. In such cases, corresponding ALLF could be implemented outside this ISDN.

FIGURE 1/I.200

ISDN network functions

2.3 An ISDN will provide a limited set of connection types to be used for a multiplicity of services. A service may be supported by any type of connection, the BLLF of which meets the requirements of the basic low layer attributes of this service.

2.4 Basic high layer functions (BHLF) and additional high layer functions (AHLF) may be implemented in specialized centres, in modes of dedicated networks as well as integrated in ISDN equipments. Whatever the implementation, user-network and user-user protocols specified for the service should consider functional entities corresponding to high layer functions as completely separate from those corresponding to connections or additional low layer functions.

Note: Definitions of Low Layer Function and High Layer Function will be attached as an Appendix.

Note - Dependent upon national regulations, HLF may be provided by administrations, RPOAs or other supplies.

2.5 The following customer entitites may be connected at the reference points S/T (as defined by Recommendation I.411) :

- customer terminals;

- customer systems, e.g. PABX, LAN;

- private networks.

All customer entities connected to ISDN interfaces at the S/T reference points must meet the specifications of the protocols at that interface of all the layers that are included in the definition of the service used.

For some services the service definition also covers some terminal functions and characteristics in addition to those specified by the protocols at the interface.

Note 1 - Customer terminals and systems may be private or provided by administrations, RPOAs.

Note 2 - Some of the ALLF identified for ISDN might also be implemented in certain categories of terminals.

2.6 The operational service features associated with a service offering may include features for maintenance, charging, user control of service features, etc. The operation of such features may involve terminal-network communication and may therefore be viewed as applications in their own right. Their specification could imply the seven layers of OSI model as well as procedural aspects that are beyond the OSI context.

Information flows used to control or manage ISDN services may involve protocols modelled by layers higher than OSI layers 1-3 (see draft Recommendation I.311), and is independent of the terms High Layer and Low Layer as used in this Recommendation.

These comments apply to network/terminal functions classification described in section 2 as well as to service classification described in section 3.

3. Telecommunication services characterization

3.1 General

A telecommunication service is provided by an administrative, RPOA, or in certain circumstances, with the cooperation of private companies. A service definition usually relates to network and terminal functions. However, I.2 ... Recommendations characterize ISDN telecommunication services at reference point S or T. Network functions are explicity defined as they appear to the user. Some of the terminal functions are implicitly defined.

Note - It may be that an ISDN provides services to other networks, possibly not at reference points S or T. This requires further study.

In the following two broad categories of services are considered :

- bearer services, and

- tele-services.

A service is characterized and described by service attributes. There are two groups of service attributes applicable to the user information flow : the low layer attributes (OSI layers 1-3) and the high layer attributes (OSI layers 4-7). Bearer services are characterized only by low layer attributes. Tele-services are characterized both by low layer attributes and high layer attributes.

The basic characteristics of a service are described by the basic service attributes. The additional characteristics of a supplementary service are described by additional service attributes.

3.2 Bearer services

Bearer services provide the capability for information transfer between ISDN interfaces and involves only functions at layer 1 and possibly layers 2 and 3 within ISDN. The customer may choose any set of high layer (at least 4-7) protocols for his communication, and the ISDN does not ascertain compatibility at these layers between customers. An example of a bearer service is a 64 kbit/s circuit switched transparent service.

A bearer service provides the user with the possibility of getting access to various configurations of communications, covering :

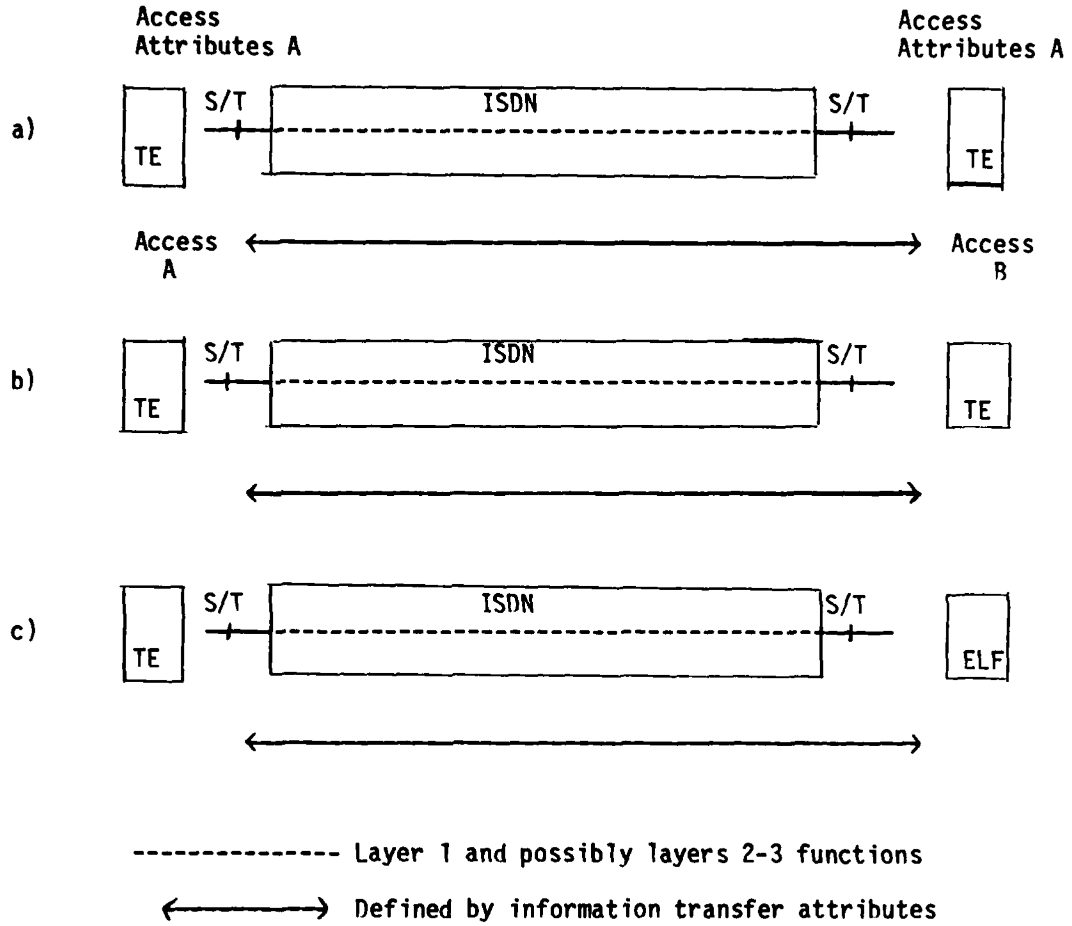
- information transfer between users employing the same access attributes at the S/T reference points involved, see Figure 2a;
- information transfer between users employing difference access attributes at the S/T reference points involved, see Figure 2b;
- information transfer between a user and a separate resource providing high layer functions, see Figure 2c.

Bearer services are characterized by a set of low layer attributes defined in Recommendation I.2xx. Low layer attributes describe the communication related characteristics of a service (basic low layer attributes) or of a supplementary service (supplementary low layer attributes). Low layer attributes refer to the functions and protocols of the layer 1 and possibly 2-3 (OSI reference model) concern the transfer of user information. Attributes defining bearer services are classified into three categories:

- information transfer attributes;
- access attributes;
- general attributes, including operational and commercial attributes.

The bearer capability defines the technical features of a bearer service as they appear to the user. For the time being the bearer capability is characterized by information transfer and access attributes. A type of bearer capability is associated to every bearer service.

Note - It is likely that some quality of service parameters (attribute number 10 in draft Recommendation I.2xx) - such as error rate or call set-up delay - should be extracted in order to form a new attribute allocated to the category information transfer. Identification and definition of such parameters requires further consideration.



Note 1 - Reference point to be defined but not necessary subject to CCITT Recommendations.

Note 2 - Further study is required on bearer services extending beyond the ISDN.

Note 3 - Further study is required on possible communications involving bearer services with different values allocated to information transfer attributes.

FIGURE 2/I.200

Examples of bearer service operation

3.3 Teleservices

Teleservices provide the full capability for communication by means of terminals, network functions and possibly functions provided by dedicated centres. A tele-service is characterized by a set of low layer attributes, a set of high layer attributes and operational and commercial attributes. Low layer attributes are those used to characterize the bearer capability (see section 3.2). High layer attributes are defined in Recommendation I.2xy. They describe message (i.e. messages on layer 7) related characteristics of a service (basic high layer attributes) or of a supplementary service (supplementary high layer attributes). They refer to the functions and protocols of the layers 4-7 (OSI) concerning the transfer, storage and processing of user messages (provided by a subscriber's terminal, a retrieval centre or a network service centre). Examples of teleservice are telephony and teletext.

An ISDN teleservice generally uses only one (or a small number of) types of bearer capability, which should be recommended by CCITT to support a given teleservice. It should be noted that in the case where more than one type of recommended bearer capability is used for a given teleservice interworking functions may be required under the responsibility of the teleservice provided. This principle does not prevent a user operating a specific application to use a terminal compatible with a given teleservice in association with a bearer capability not recommended for this teleservice.

3.4 In addition to services that clearly fall into the two categories defined above, there may be other services which possibly could constitute one or more further categories. Examples of such services might be services providing information handling at higher layers but which do not cover terminal functions in addition to those specified by the protocol at the terminal interface.

The possible definition of an additional category of services for such services is for further study.

4. Relations between service categories and functional elements

The services and supplementary services are realized in the network and the terminals by the ISDN capabilities and terminal capabilities, i.e. basic and additioal low and high layer functions. These functions are composed of network and terminal functions.

Table 2/I.200 gives an overview about the structure of and the relation between service attributes, low/high layer functions, and network/terminal functions.

Figure 3/I.200 gives an example of teleservice operation through an ISDN.

It should be noted that for a telecommunication service, the terminals may provide functions similar to ALLF or MLF supported by an ISDN.

Network functions are specified in Recommendation I.2 ... .

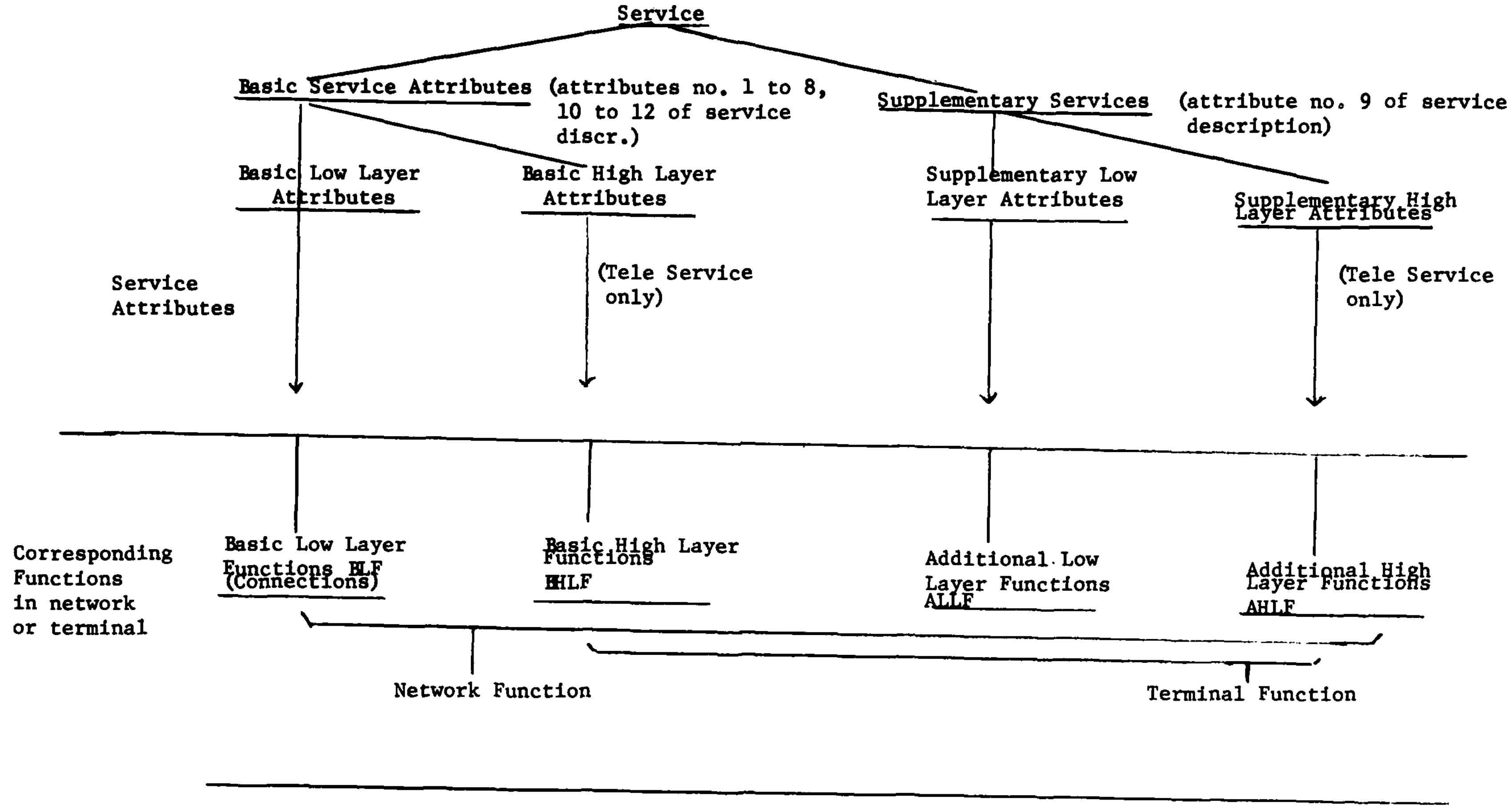
5. Provision of telecommunication services

5.1 General

Depending on the nature of the customer ownership within the subscriber premises (TE, or TE and NT2) a telecommunication service is provided at S or T reference point.

TABLE 2/I.200

Structure of and relation between service arrtibutes, low/high layer functions and functional elements



A.008

Note 3 - Definition of HLF attributes have not been defended and require FS.

Note 4 - Network functions are defined in I.300 and I.325.

Notes to Table 2/I.200

Note 1 - Attributes 1-12 are defined in Recommendation I.2xx.

Note 2 - A supplementary service cannot be offered as a stand alone entity. The attribute No. 9 is mainly concerned by supplementary services and could be split into sub-attributes depending on results of further studies.

Supplementary services could also have an influence on basic service attributes (1-8, 10-12); this also requires further consideration.

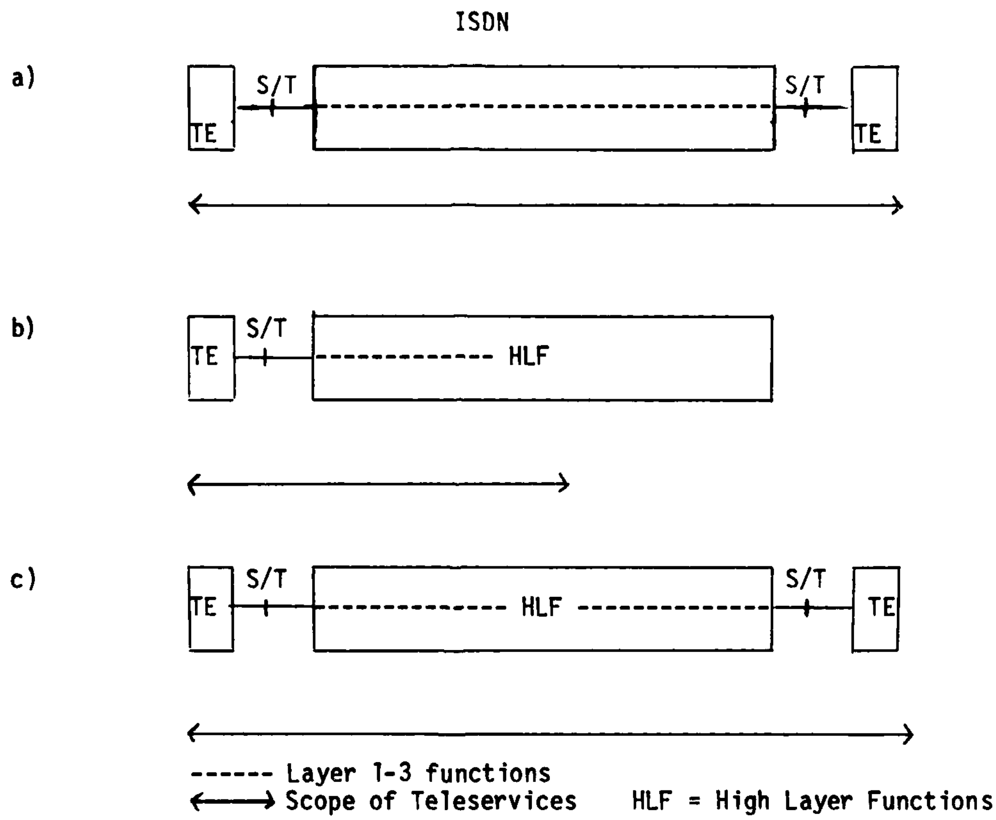


FIGURE 3/I.200

Examples of teleservices

5.2 Provision of teleservices

A teleservice provider offers services to users insofar as it knows them as using this service, for instance, and makes arrangements to allow open communications (in addition to public network capabilities of layers 1 to 3); for instance:

- registration into a service directory, that corresponds to a subscription ensuring the service access,

- provision of possible HLF allowing for instance some interworking capabilities (eg. Telex- Teletex).

6. Some aspects of Teleservice Interworking

An administration or RPOA may provide service interworking between certain equipment attached to the networks. Two possibilities should be considered:

i) The equipment is certified as consistent with standards relevant to the networks service, in which case appropriate service interworking is available.

ii) The equipment is recognized as being able to be connected to the network without disturbing it. In this case, the network cannot necessarily make service interworking available.

APPENDIX:

Low Layer Function: The low layer functions are the realization of the low layer attributes. They are related to the layers 1 to 3 (OSI). They may be implemented in the network, terminals or both.

There are distinguished basic low layer functions (BLLF), which realize the basic low layer attributes of a service, and the additional low layer functions (ALLF), which realize the supplementary low layer attributes of a supplementary service.

High Layer Function: The high layer functions are the realization of the high layer attributes. They are related to the layers 4 to 7 (OSI). They may be implemented in the network (network service center), terminals (incl. retrieval centers) or both.

The distinction is made between the basic high layer functions (BHLF) realizing the basic high layer attributes of a service and the additional high layer functions (AHLF) realizing the supplementary high layer attributes of a supplementary service.

Temporary Document 44-E

CCITT

STUDY GROUP XVIII

Geneva, 21 November - 2 December 1983

ANNEX 1

NEW DRAFT RECOMMENDATION I.2xx (REVISED VERSION OF PART II OF I.200 IN COM XVIII-R 20)

Draft Recommendation I.2xx

BEARER SERVICES SUPPORTED BY AN ISDN

Considering

- the ISDN concept described in Recommendation I.120,

- the ISDN functional architecture model described in draft Recommendation I.310,

- the ISDN protocol reference model described in draft Recommendation I.311,

- the ISDN connection types described in draft Recommendation I.3xx

- the ISDN user-network interface reference configurations described in draft Recommendation I.411,

- the principles for defining ISDN services described in draft Recommendation I.200,

an ISDN will support a wide variety of services. The purpose of this Recommendation is to provide a description of such services to be used as a basis for defining the network capabilities required by ISDN.

1. Framework for describing ISDN bearer services

ISDN bearer services are described by a number of attributes, which are intended to be largely independant. They are grouped into three categories :

i) Information transfer attributes, which characterize the network capabilities for transferring information from one S/T interface to one (or more) other S/T interfaces;

ii) Access attributes, which describe the means for accessing network functions/facilities as seen at one S/T interface; and

iii) General attributes, which deal with the service in general.

Figure 1/I.2xx shows the relation between the groups of attributes and the parts of the service where the attributes are defined.

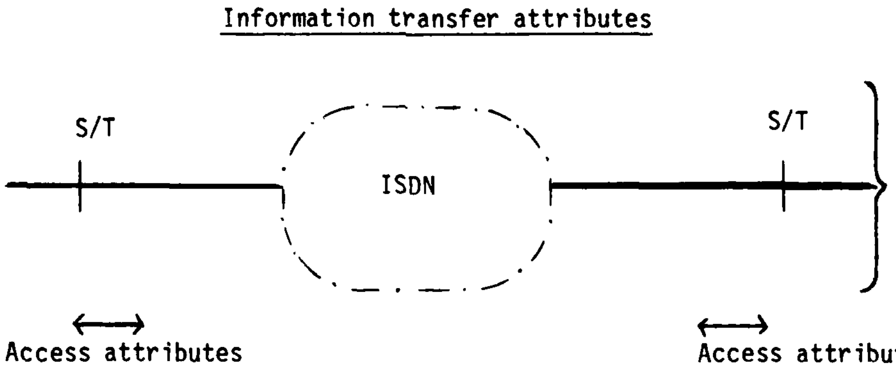


FIGURE 1/I.2xx

Table 1/I.2xx gives the list of the attributes

TABLE 1/I.2xx

Information transfer attributes

1 - Information transfer mode
2 - Information transfer rate (Note 1)
3 - Type of information transfer capability
5 - *Establishment of communication*
7 - Symmetry
6 - Information transfer configuration
4 - Structural integrity

Access attributes (Note 2)

8 - Access channel and rate (Note 1)
9 - Access protocol

General attributes

10 - Supplementary services/facilities provided
11 - Quality of service
12 - Interworking possibilities
13 - Operational and commercial

Note 1 - Attribute 2, information transfer rate, describes the rate at which information can flow from one user to another. Examples are bit rate for circuit switched services and throughput for packet switched services. Attribute 8, Access channel and rate, describes the bit rate of the channel at a given user-network interface.

Note 2 - Different access attributes may apply at each of the (two or more) network interfaces involved in the use of a bearer service.

Figure 2/I.2xx presents a list of possible values for each attribute. Where options exist for a given attribute, the section is subject to agreement between the customer and the administration. A detailed descriptions of the attributed values is given in appendix 1 (see TO.45).

Possible values of attributes							Attributes
							Information transfer attributes
circuit	packet						1. Information transfer mode
Bit rate options for further study	throughput options for further study						2. Information transfer rate
unrestricted digital information	speech	3.1 kHz audio	7kHz audio	15kHz audio	video	Other for further study	3. Type of information transfer capability
demand	reserved	permanent					5. Establishment of communication
simplex	duplex symmetric	duplex asymmetric					7. symmetry
point-to-point	multipoint						6. Information transfer configuration
8 kHz	Service data unit integrity	unstructured					4. Structural integrity
							Access attributes
D(16)	D(64)	B	Other options for further study				8. Access channel and rate
under study							9. Access protocol
							General attributes
under study							10. Supplementary services/ facilities provided
							11. Quality of service
							12. Interworking possibilities
							13. Operational and commercial

FIGURE 2/I.2xx

Possible values for each attribute

2. Description of bearer services

This section describes several bearer services accessed via the standard network access provided by an ISDN. The identification and description of possible additional services such as subrate services are left for further study.

These possible additional services would not lead to adding additional requirements to those already identified for physical characteristics of interfaces to be applied at reference points S and/or T (see draft Recommendation I.411).

2.1 Circuit mode bearer service

These ISDN bearer services are typically characterized by the provision of user information over one type of channel and signalling over another type of channel.

2.1.1 Circuit 64 kbit/s unrestricted

An unrestricted bearer service provides information transfer without alterations between S/T reference points. It may, therefore, be used to support various user applications. Examples include :

1) speech;

2) multiple subrate information streams multiplexed into 64 kbit/s by the user;

3) transparent access to a X.25 public network (I.472).

User information is transferred over a B channel, signalling is provided over a D channel.

Attributes/values

Information transfer attributes

1. Mode : Circuit
2. Rate : 64 kbit/s
3. Information type : Unrestricted
4. Structure : 8 kHz
5. Establishment : Demand/reserved/permanent
6. Configuration : Point-to-point (Note 1)
7. Symmetry : Duplex-symmetric/simplex

Note 1 - Multipoint may be an additional configuration.

Access attributes

8. Access channel : B for user information, D for signalling (Note 2)
9. Access protocol : I-series for D channel

Note 2 - For reserved/permanent service the operational, administrative and maintenance messages related to these services may be conveyed over the D channel.

General attributes

10. Supplementary services/facilities :
11. Quality of service : for further study
12. Interworking possibilities :
13. Operational and commercial aspects :

2.1.2 Circuit 64 kbit/s, usable for speech information transfer

This service is similar to the unrestricted service (2.1.1) except that the digital signal at the S/T reference point follows the international agreed encoding laws for speech (i.e. A-law, u-law) and that the network may use digital signal processing techniques, such as echo cancellation and low bit rate voice encoding. Hence, it integrity is not assured.

Attributes/values

1-2 : Same as 2.1.1
3 : Information type : Speech (encoded according to A-law, u-law)
4-9 : Same as 2.1.1
10-13: For further study (may be different from 2.1.1)

Due to the lack of time the following bearer service descriptions are not aligned yet to the new list of attributes. They are :

2.1.2 Circuit 64 kbit/s, usuable for voice-band data information transfer - further study

2.1.3 384 kbit/s leased-circuit services

These services provide for transport (with or without modification)*) of 384 kbit/s user information offered over an H0 channel. Operational, administrative and maintenance information may be carried over a D channel.

Attributes/Values

Information transfer attributes

1. Mode : circuit
2. Rate : 384 kbit/s
3. Symmetry : Duplex-symmetric/Duplex-asymmetric/Simplex
4. Configuration : point-to-point/point-to-multipoint
5. Transparency : transparent/non-transparent

Access attributes

6. Access Channel Type and Rate : H0 for user information
   D for OA-M information
7. Access protocol : I-series protocol
8. Establishment of a connection non-switched/reserved

General attributes

9. SS/F available for further study
10. QOS : for further study
11. Interworking possibilities : for further study
12. Operational and commercial : for further study

2.1.4 1536 kbit/s Switched Service

This service provides for transport (without modification) of 1536 kbit/s user information offered over a H11 channel. Operational, administrative and maintenance information may be carried over a D channel.

Attributes/Values

Information transfer-attributes

1. Mode: circuit
2. Rate: 1536 kbit/s
3. Symmetry : two-way/one-way
4. Configuration : point-to-point/point-to-multipoint
5. Transparency: transparent

Access attributes

6. Access Channel Type and Rate : H11 for user information
   D for OAM information
7. Access protocol: I-series protocol
8. Establishment of connection: switched (on demand)/reserved

General attributes

For further study

2.1.5 1920 kbit/s switched service

This service provide for transport (without modification) of the 1920 kbit/s user information offered over a H12 channel. Operational, administrative and maintenance information may be carried over a D channel.

Attribute/Values

Information transfer-attributes

1. Mode: circuit
2. Rate: 1536 kbit/s
3. Symmetry: two-way/one-way
4. Configuration: point-to-point/point-to-multipoint
5. Transparency: transparent

Access attributes

6. Access Channel Type and Rate: H12 for user information
   D for OAM information
7. Access protocol: I-series protocol
8. Establishment of connection: switched (on demand)/reserved

General attributes

for further study.

2.2 Packet-mode bearer services

These bearer services involve packet handling functions (PHF). Depending on the resources of the local access which are involved, three bearer services can be identified :

2.2.1 Virtual circuits

This service provides for transport (without modification) of user information in a packetized manner.

Attributes/Values

Information transfer attributes

1. Mode : Packet - virtual circuit
2. Rate : Maximum instantaneous throughput of a given virtual circuit is less than or equal to the host channel rate
3. Symmetry : Duplex-symmetric
4. Configuration : point-to-point
5. Transparency : transparent

Access attributes

6. Access channel type and rate : logical channel within B or D channel. When D channel is used maximum packet size and quality of service may be restricted.
7. Establishment of connection : switched virtual circuit or permanent virtual circuit
8. Access protocol : X.25 level 3 X.25 LAP B level 2 or I.441 when the virtual circuit is carried on a B channel; I.441 when the virtual circuit is carried on a D channel.

Note : Virtual circuits on a D channel provided by other access protocols are for further study.

General attributes

9. Supplementary services/facilities available : for further study; candidates include those specified in CCITT Recommendation X.2
10. Quality of service : for further study
11. Interworking : for further study
12. Operational and commercial : for further study

2.2.2 Connectionless packet service on a D channel

This service might be provided to support applications such as telemetry, telealarm and telecontrol. Further studies could indicate specific constraints on this bearer service, such as technical performance or user throughput; it can however be envisaged that it caters also for other applications (e.g. credit card checking).

Attributes/Values

Information transfer attributes

1. Mode : packet - connectionless
2. Rate : the maximum rate at which connectionless packets may be transferred is less than or equal to the D-channel rate
3. Symmetry : Simplex
4. Configuration : point-to-point
5. Transparency : transparent

Access attributes

6. Channel type and rate : within a D channel
7. Protocol : for further study
8. Establishment of connection : not applicable

General attributes

9. Supplementary services-facilities available : for further study
10. Quality of service : for further study
11. Interworking possibilities : for further study
12. Operational and commercial : for further study.

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Temporary Document No. 32-E

STUDY GROUP XVIII

Geneva, 21.11 - 2.12.1983

Question 1B/XVIII

SOURCE: WT3 drafting group on Addressing

TITLE: Report of Meetings

1. This drafting Group met on Nov 24-25 to consider issues related to ISDN numbering and addressing. The group was chaired by Eric Scace (USA GTE Telenet). Among the contributions considered were TB, TC, TJ, SL, SM, VI, and UF, and Temp. 1 from SG II.

As a result of the discussion, an updated version of Rec. I.320 was produced and is attached to this report.

2. Destination Network: It was agreed that the SG II conclusion that a destination network identification (when needed) is included inside the national ISDN number. No firm conclusions were reached to express a preference between methods 1 and 2 for including this identification, which were outlined by SG II. Method 3 is not applicable when the destination network designator is included in the National ISDN number.

3. Subaddressing and DDI: It was agreed that digits for DDI are included inside the ISDN number.

It was agreed that the subaddress would be supplied to and deliver by, an ISDN with procedures which are independent of the actual length of the subaddress. In other words, a one-digit subaddress is procedurally treated the same way as a 32-digit subaddress at the origination and destination user-network interfaces.

It was agreed that the information element conveying the subaddress is separate from the information element conveying user-user information at, e.g., call establishment time. User-user information is considered to be completely unstructured, while the subaddress has structure and format limitations. This conclusion appears consistent with the existing status of Rec. I.451 (Q.930).

It was agreed that it shall be possible to distinguish between the ISDN number and subaddress in all cases. Therefore, a function shall be provided to mark the end of the ISDN number. Another function shall be provided to mark the end of the ISDN address. The exact definition of the implementation of this function is left to the responsibile Study Groups. For example, WP XI/6 has defined in the current draft Rec. I.451 (Q.930) for conveying the ISDN number and subaddress in separate, consecutive information elements. Each element is identified by the "type of address" field as containing a number or sub-address.

It was agreed that not all calls will have subaddress information to convey.

The charging implications of carrying various sizes of subaddress are left for Study Group III's consideration.

It was proposed that the subaddress may also be structured such that the first portion might be used for terminal identification without using DDI or other capacity from the ISDN number space (e.g., in the case of a passive bus). However, most organizations did not agree with this proposal. Among the concerns raised during an extensive discussion were the implications on the maximum length of the subaddress; the implications on the ability to use the subaddress to convey OSI NSAP addresses; the view that such a terminal selection function, if required, should be done within the ISDN number; and concerns about the portability of such passive bus TEs which have to memorize such a number.

It was agreed that the maximum length of the subaddress shall be 32 decimal digits.

4. Interworking.

It was agreed that, for calls originated by ISDN subscribers to subscribers on other types of networks, the destination address may contain a number from another numbering plan. For example, a call to a PDN subscriber may be placed using an X.121 address as the destination address. To facilitate this interworking, an explicit indication of the pertinent numbering plan should be provided in the address information elements of Rec. I.451. Since this indication can be conveyed in e.g., octet 3 along the type of address, there appears to be no need for definition of prefix or escape digit sequences in the user-network interface procedure for interworking purposes.

It was reaffirmed that the single stage method of interworking shall be the preferred method; SG II and XI are requested to develop procedures to accomplish single stage interworking.

It was felt that, for calls from subscribers of other types of networks of ISDN subscribers, the definition of procedures for interworking (including the conveyance of the ISDN address) should be developed by the Study Group responsible for each type of other network.

The provisional maximum length of the ISDN number of 15 digits, chosen by SG II, seemed generally adequate to perform the functions envisioned for ISDN numbers.

5. Prefix and escape codes.

It was agreed that there appeared to be no need for prefix or escape codes/functions to be defined.

6. Transit network selection (when permitted).

It was noted that I.451 provides an identification of selected transit networks (when permitted) in information elements distinct from those information elements conveying ISDN addresses. This is consistent with our earlier agreements.

7. Other topics.

It was agreed that, in principle, when Rec. E.16n becomes available as a Recommendation, Rec. I.320 will be reviewed to removed duplication with E.16n.

It was agreed that, from an addressing viewpoint, mobile subscribers are like fixed subscribers; i.e., mobile subscribers have TEs, reference points S and T, NT1, and may have NT2. Therefore, an ISDN number has the same ability to unambiguously identify points in mobile subscriber premises as it has for fixed subscriber premises.

After an detailed discussion in an editing group, it was recognized that multipoint configurations have certain addressing implications. For example, on a passive bus, should it be possible to select a single TE solely by addressing information (i.e., within one category of service, compatibility, etc.)? To make such a selection appears to require the TE to store and recognize its address. Discussions so far have not explicitly excluded such TE capabilities. But many participants felt that TEs should not be obliged to remember their address.

During the discussion, it was agreed to place $3 on the relationship between OSI NSAP addresses and ISDN addresses in an Annex. It was also agreed that ISDN addresses may be associated with applications which are not in the "OSI environment", as well as with OSI applications.

It was agreed that further study is needed on the principles for describing how a call is routed to a user, based on, e.g., addresses, compatibility information, service identification, etc. Therefore, contibutions on this topic are solicited, including aspects of call delivery such as closed user groups, for beginnning the development of Rec. I.321 on routing principles.

Draft Recommendation I.320

ADDRESSING AND NUMBERING PRINCIPLES IN ISDN

1. Introduction

1.1 This recommendation provides the general concepts, principles, and requirements for addressing reference points located at subscriber premises, for addressing other functions, and for allowing communications with TEs. This recommendation defines the requirements for applying the numbering plan to ISDN.

Further study is required on the principle of describing how a call is routed to a user based on, e.g., address and service indication. (see Rec. I.321)

1.2 The following understanding of relevant nomenclature is established:

a. an ISDN number is one which relates to an ISDN network and ISDN numbering plan.

b. an ISDN directory number is that which may be listed in public directories against the subscriber's name.

c. an ISDN address comprises the ISDN number and the mandatory and/or optional additional addressing information.

d. private communications facilities are communications capabilities confined to use by one or more particular subscribers, as opposed to facilities which are shared by subscribers of public networks. Examples of private communications facilities include LANs, PABXs and other private network arrangements.

1.3 Depending on the different cases and stages identifiable within an addressing process, an ISDN number may be :

a. an international ISDN number, or

b. a national ISDN number, or

c. an ISDN subscriber number.

An ISDN address comprises :

d. the ISDN number, and

e. mandatory and/or optional additional addressing information.

1.4 As an objective, all ISDNs should evolve towards a single numbering plan, namely the ISDN numbering plan. Considering the wide penetration of the telephone network in the world and its existing resources, the ISDN numbering plan should be developed by enhancing Recommendation E.163. Therefore, it is recommended that the telephone country code (TCC) be used to identify a particular country*.

1.5 An existing numbering plan may interwork and thus coexist with the ISDN numbering plan. All interworking cases from ISDN to dedicated networks, and vice versa, have to be covered by the appropriate Study Groups. Preference should be given to single stage selection methods whenever possible.

It is recognized that some of the present data networks, for instance, could retain the X.121 numbering structure and interwork with ISDNs. Necessary interworking arrangements should be studied for securing interconnectability between ISDNs employing the ISDN numbering plan and e.g., multiple service networks evolving from data networks using the X.121 numbering structure.

2. Principles for Relating an ISDN number to ISDN User-Network Reference Configurations

2.1 An ISDN number shall be able to unambiguously identify a particular:

a. physical interface at reference point T. See Figure 1/I.320

b. virtual interface at reference point T; i.e., for a NT2+NT1 configuration. See Figure 2/I.320.

c. Multiple interfaces (physical or virtual) at reference point T. See Figure 3/I.320.

d. for point-to-point configurations, physical interface at reference point S. See Figure 4/I.320.

e. for point-to-point configurations, virtual interface at reference point S. See Figure 5/I.320.

f. for point-to-point configurations, multiple interfaces (physical or virtual) at reference point S. See Figure 6/I.320.

g. for multi-point configurations (e.g., passive bus), all of the interfaces are reference point S. See Figure 7/I.320. It was agreed after a review of the potential uses of ISDN addresses that, from the viewpoint of the network side of the interface, an ISDN address is associated with one (or a multiple of) D-channel used to signal to the user.

Note - The ability to select one TE in a multi-point configuration (e.g., passive bus) solely by address information is for further study.

2.2 A particular interface, or multiple of interfaces, may be assigned more than one ISDN number. An example is shown in Figure 8/I.320.

2.3 All ISDNs shall be able to assign an ISDN number to an interface at reference point T or S. However a particular ISDN number fulfills only one of the functions identified in 2.1 above.

2.4 For mobile services an ISDN number shall be capable of unambiguously identifying an interface in the mobile subscriber's premises, as defined in Section 2.1 See Figure 8/I.320.

2.5 The ISDN number is not required to identify a particular connection where, on a particular interface, more than one connection may be present at a given instant.

2.6 The ISDN number is not required to identify directly a particular channel, where, within a particular interface, there may be more than one channel. Indirect identification of particular channels may occur; e.g., when the ISDN number identifies a particular interface and there is a one-to-one correspondence between that interface and particular channels.

3. Relationships between ISDN number transit network/880A selection (when permitted), service indication, and quality of service indication.

The establishment of an ISDN connection will require an ISDN address. In addition, separate non-address-related information may be necessary for completing a connection.

3.1 Routing of ISDN connections shall take into account the following information, when supplied by the user :

a. ISDN numbers, including destination network identification (network identification code, NIC) and digits for direct dialling in (DDI) where applicable.

b. service identification, possibly including requested quality of service parameters such as transit delay throughput, and security.

c. multiple transit RPOA/network selections, when permitted.

Note: The need for remote transit RPOA/network selection by the user of an ISDN which has no local transit RPOA/network selection is for further study.

Transit RPOA/network selection by the user, when permitted, or by the originating ISDN, shall be evaluated in the routing of a connection.

In national networks on a particular connection, the user may choose to specify some or all of this information, at either subscription time or connection-establishment time.

The ISDN number does not identify the particular nature of the service, type of connection, or quality of service to be used, nor transit RPOA/network.

3.2 In the case where an ISDN number identifies a mobile TE or a TE served by several interfaces or networks, an ISDN may need to map from the ISDN number into a specific interface designation.

4. ISDN Number Design Considerations

Note: Numbering Plan design information covered by Recommendation E.16m will be deleted when Recommendation E.16m becomes available.

4.1 The ISDN number shall include an unambiguous identification of a particular country*).

*) or geographic area.

The ISDN number is allowed to include an unambiguous identification of a particular geographic area within a country. *)

4.2 As an objective, all ISDNs should evolve towards a single numbering plan. However, an existing numbering plan may interwork and thus coexist with the ISDN numbering plan.

4.3 When a number of public or private ISDNs exist in a country, it shall not be mandatory to integrate the numbering plans of the ISDNs. Methods for interworking are for further study, with the objective that connections between the TEs on these various networks can be completed by using only the ISDN address.

4.4 The ISDN number shall be capable of containing an identification of the ISDN to which the called user is attached. For a private network which spans more than one country, the country code will cause delivery of a connection in the specified country to the particular private network.

4.5 The ISDN number shall be capable of providing for interworking of TEs on ISDNs with "TEs" on other networks. As an objective, with respect to the ISDN number, the procedure for interworking should be the same for all cases. The single-stage method of interworking is the preferred approach.

5. Structure of the ISDN address

5.1 The structure of the ISDN address is illustrated in Figure 10. A function marking the end of the ISDN number shall always be provided, even when no subaddress is present. An end of address is also required. When there is no subaddress present, the end of number and end of address functions are coincident.

5.2 The ISDN address shall be a sequence of decimal digits. The ISDN number shall include the capability of Direct Dialing In.

5.3 The ISDN address may be of variable length.

5.4 International ISDN number.

5.4.1 The international ISDN number may be of variable length. Minimum and maximum lengths should be prescribed and are for further study. A reasonable limit on the overall number of digits shall be imposed.

5.4.2 In a particular international ISDN number, the exact number of digits shall be governed by national and international requirements.

5.4.3 The ISDN numbering plan shall provide substantial spare capacity to accommodate future requirements.

5.5 ISDN sub-address

5.5.1 All ISDNs shall be capable of conveying the ISDN sub-address transparently.

5.5.2 Special attention is drawn to the fact that sub-addressing is not to be considered as part of the numbering plan, but constitutes an intrinsic part of the ISDN addressing capabilities. The sub-address shall be conveyed in a transparent way as a separate entity from both ISDN number and user-to-user information. A maximum length shall be 32 decimal digits.

6. Representation of ISDN address

6.1 At the person-machine interface, the objective is to establish one method of distinguishing between abbreviated and complete representations of an ISDN number. This method is for further study. International recommended methods will be chosen.

6.2 The method to distinguish between an ISDN number and a number from another numbering plan shall be by a separate identification of the applicable numbering plan. If such methods are required, international recommended procedures will be chosen.

ANNEX A
(to Recommendation I.320)

Interworking with dedicated networks

A1. At an interface between an ISDN and a dedicated bearer service public network, the interworking unit shall convert between ISDN addresses and dedicated bearer service network numbers, when required.

A2. TE1s are always allowed to use ISDN numbers when originating a connection. Some ISDNs may also allow other numbers to be used. In this case such numbers shall be conveyed with an identification of the relevant numbering plan.

A3. When a TE2 call user of an existing dedicated bearer service network, the TE2 may use the dedicated bearer service number. In the case of a TE2 placing an outgoing call via an ISDN which uses only the ISDN numbering plan, the dedicated bearer service number will be converted into an ISDN number.

A4. When a terminal on a dedicated bearer service network calls an ISDN interface which has been assigned an ISDN number, the terminal on the dedicated bearer service network must use the appropriate dedicated bearer service procedure for indicating the ISDN address. This procedure should be developed by the study group reponsible for that dedicated bearer service network.

ANNEX B
(to Recommendation I.320)

Principles Relating ISDN Numbers to the X.200 Reference Model

In the X.200 reference model, addresses identify service access points at each layer. As the essential purpose of the Network Layer is to achieve routing of information within the Open Systems Interconnection Environment, the ISDN number has to be related to the X.200 Network Layer Service access point, when needed. There are also cases where an ISDN address identifies a non-OSI end system.

The ISDN address includes the OSI network layer address, and thus provides the capability to identify OSI network layer service access points.

When needed, the ISDN number is related to the OSI network layer address according to the following methods :

a) For some OSI network layer addresses, the ISDN number is identical to the OSI network layer address.

b) For other OSI network layer addresses, the ISDN number is contained in the OSI network layer address. The remainder of the OSI network layer address is conveyed in the ISDN sub-address.

c) For the remaining OSI network layer addresses, the ISDN number may be derived from the OSI network layer address. The entire OSI network layer address can also be conveyed in the ISDN sub-address.

The ISDN address is not directly related to a physical, data link, transport, session, presentation or application layer entity, entity instance, or service access point. Indirect relationships may occur as one or some of these entitites or service access points may be in correspondence with network layer service access points.

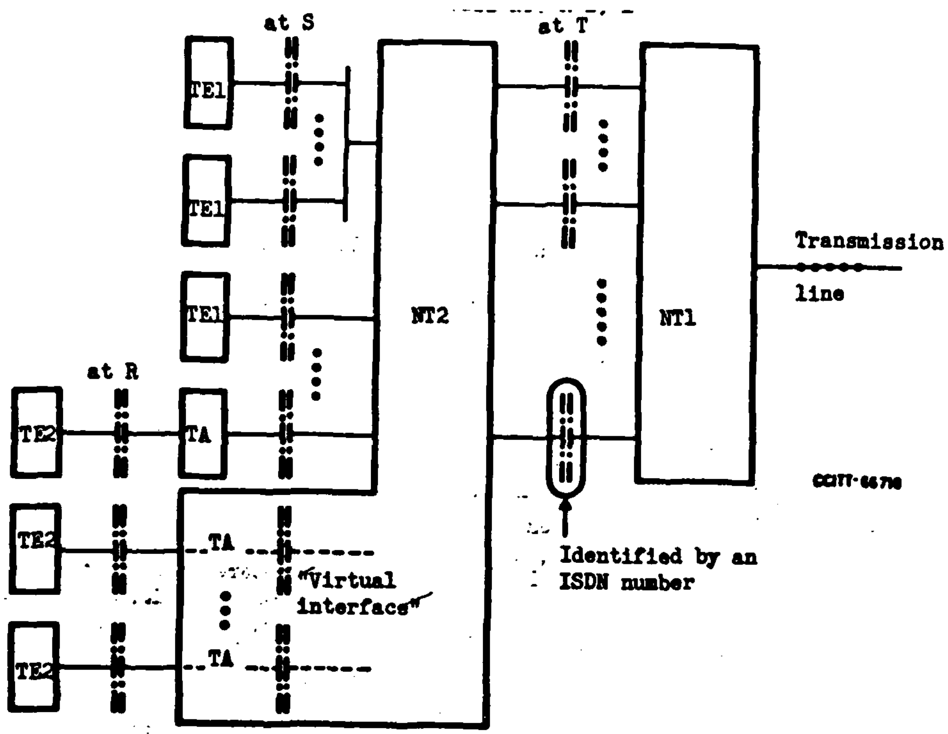


Figure 1/I.320 - Example of an ISDN number identifying a particular interface at reference point T

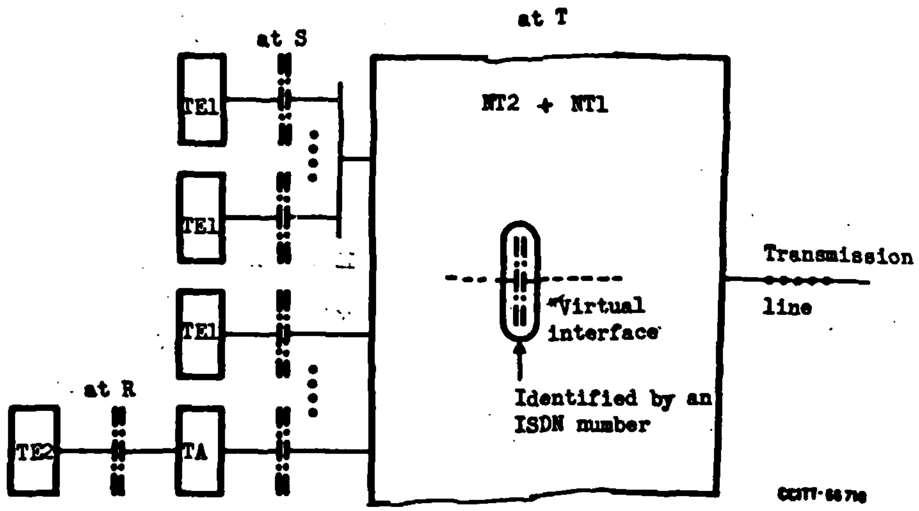


Figure 2/I.320 - Example of an ISDN number identifying a particular virtual interface at reference point T

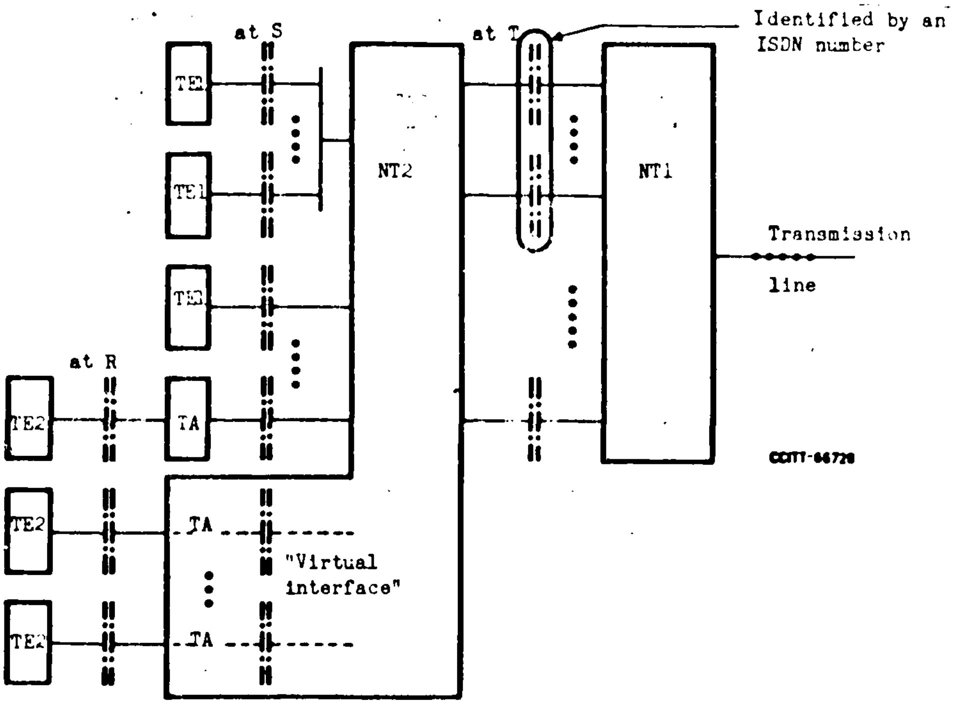


Figure 3/I.320 – Example of an ISDN number identifying a particular
(2762) multiple of interfaces at reference point T

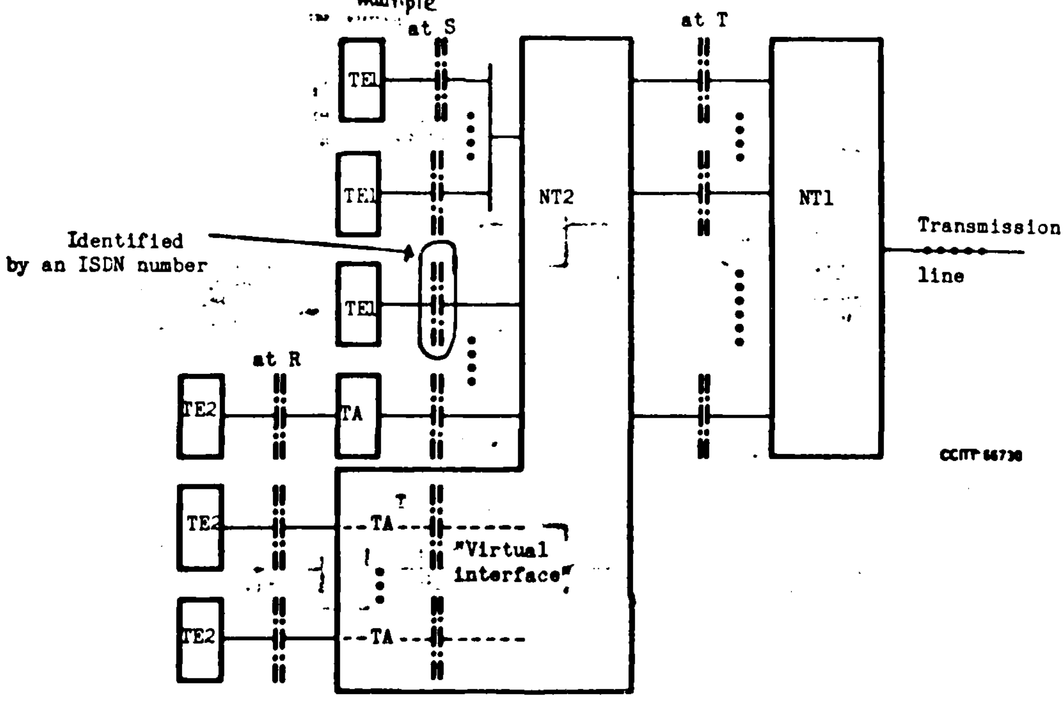


Figure 4/I 320

Example of DDI using an ISDN number identifying a particular physical interface at reference point S in a point-to point configuration.

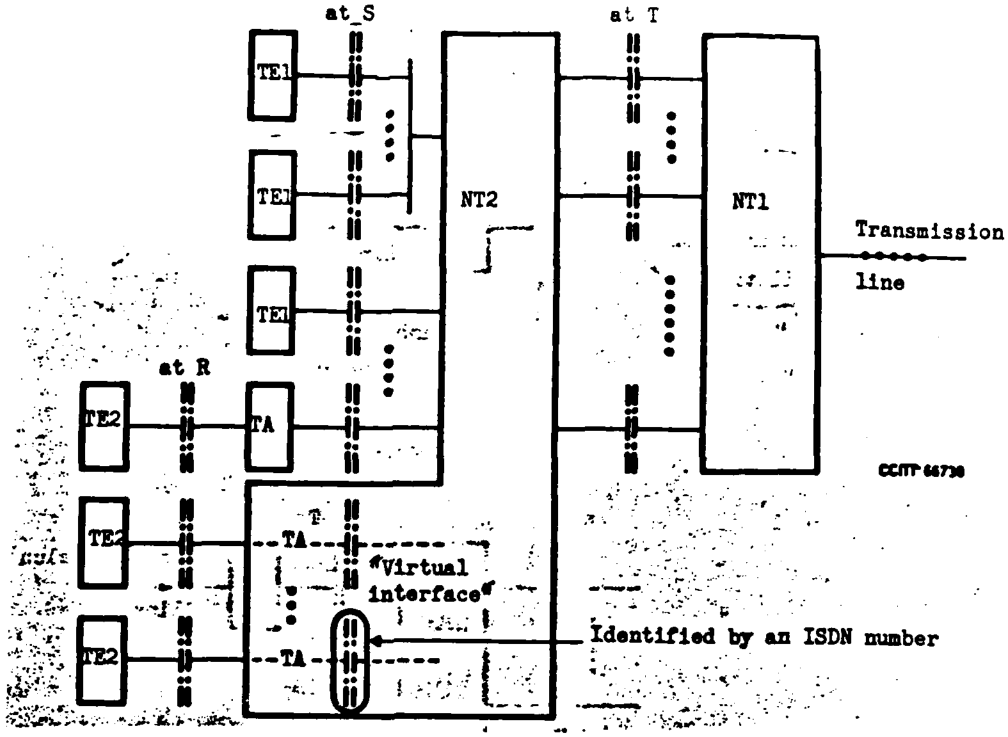


Figure 5/I.320 Example of DDI using an ISDN number identifying a particular "virtual interface" at reference point S.

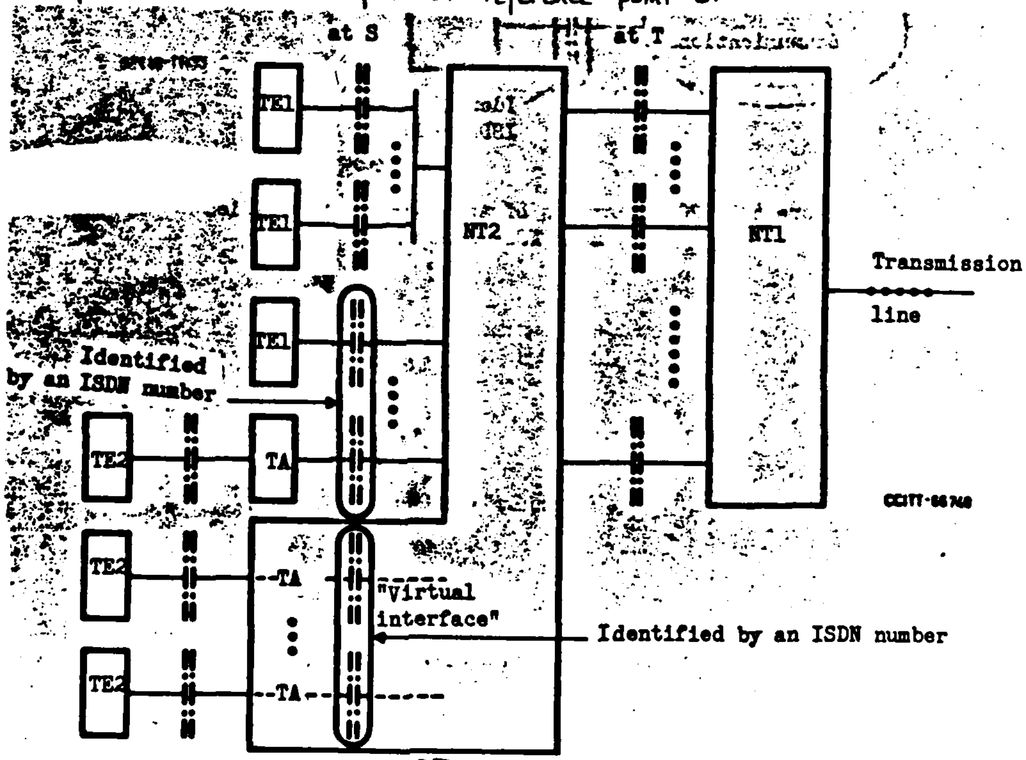


Figure 6/I.320 - Examples of DDI using ISDN numbers, each identifying a particular multiple of interfaces at reference point S in a point-to-point configuration.

(2762)

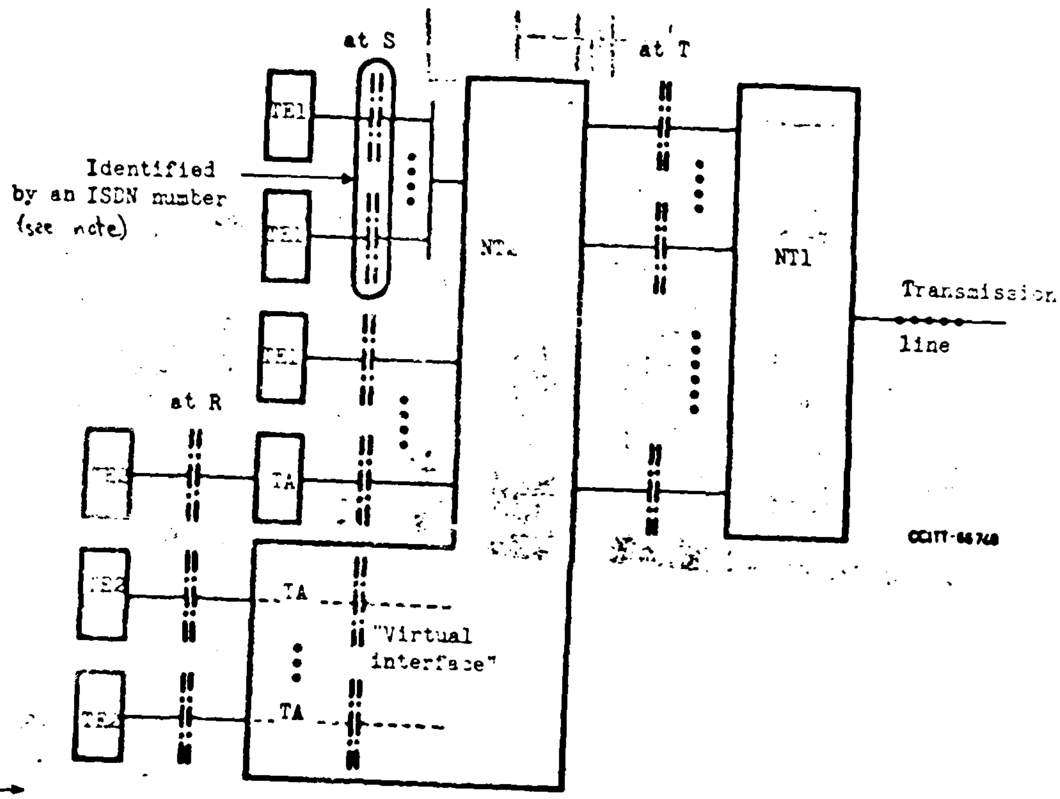


Figure 7/I.320 Example of DDI using an ISDN number identifying all of the interfaces at reference point S in a multi-point configuration.

Note – The ability to select one TE solely by use of address information is for further study.

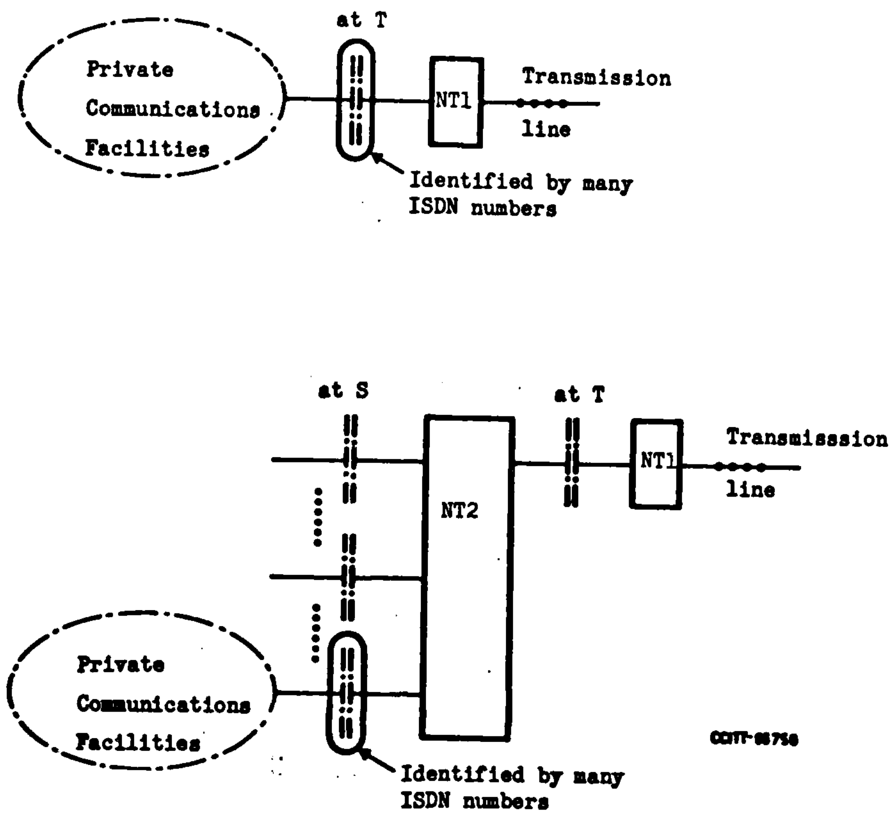


Figure 6/I.320 - Examples of an interface identified by many ISDN numbers

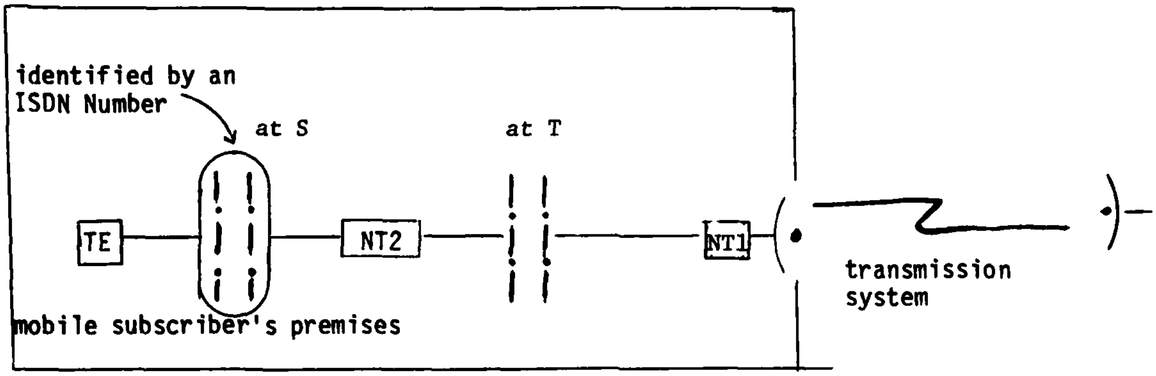


Figure 9/I.320 - Example of an ISDN number identifying a mobile TE

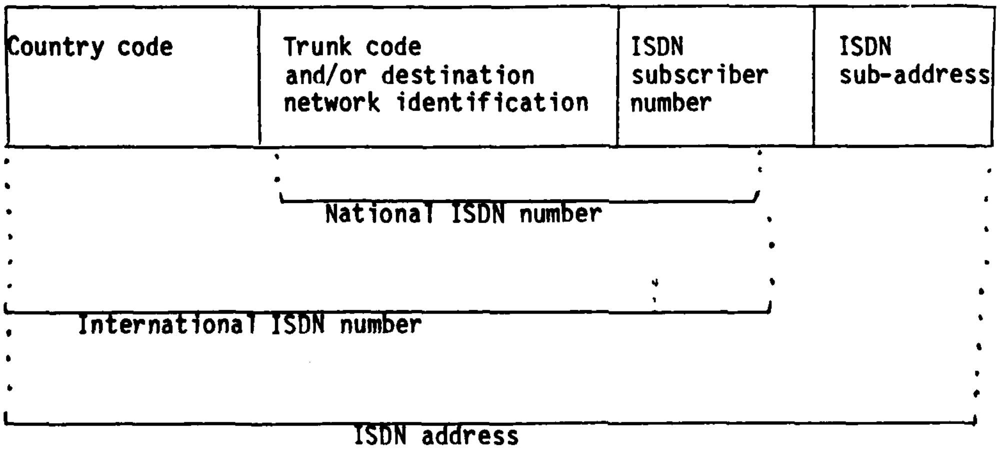


Figure 10/I.320 - Structure of the ISDN address

CCITT

STUDY GROUP XVIII

Temporary Document 34-E

Geneva, 21 November - 2 December 1983

Question : 1/XVIII, p.B

SOURCE : CHAIRMAN, WORKING TEAM 3

TITLE : ISDN - NETWORK FUNCTIONAL PRINCIPLES (I.300)

In deliberations over the weekend on the draft of the ISDN Functional Model prepared by M. Jezequel for inclusion into I.311, the suggestion was made to retain a separate document.

The new document is proposed as an overview and introduction of the network series of Recommendations to be called I.300. A draft of I.300, based on M. Jezequel's text is attached for discussion.

Draft Recommendation I.300

ISDN - NETWORK FUNCTIONAL PRINCIPLES

1. General

This Recommendation outlines the functional principles of the network aspects of the ISDN as an introduction to the network series of Recommendatons on the ISDN.

The objective of this Recommendation is to provide a common understanding of the ISDN network series of Recommendations by developing functional groupings of ISDN capabilities and their respective relationships.

2. Relationship with other I-series Recommendations

The ISDN is defined in Recommendation I.120. The services supported by an ISDN are given in the I.200 series of Recommendations. The network capabilities are defined in the I.300 series of Recommendations. The key network Recommendations and the relationship between them is shown in Figure 1.

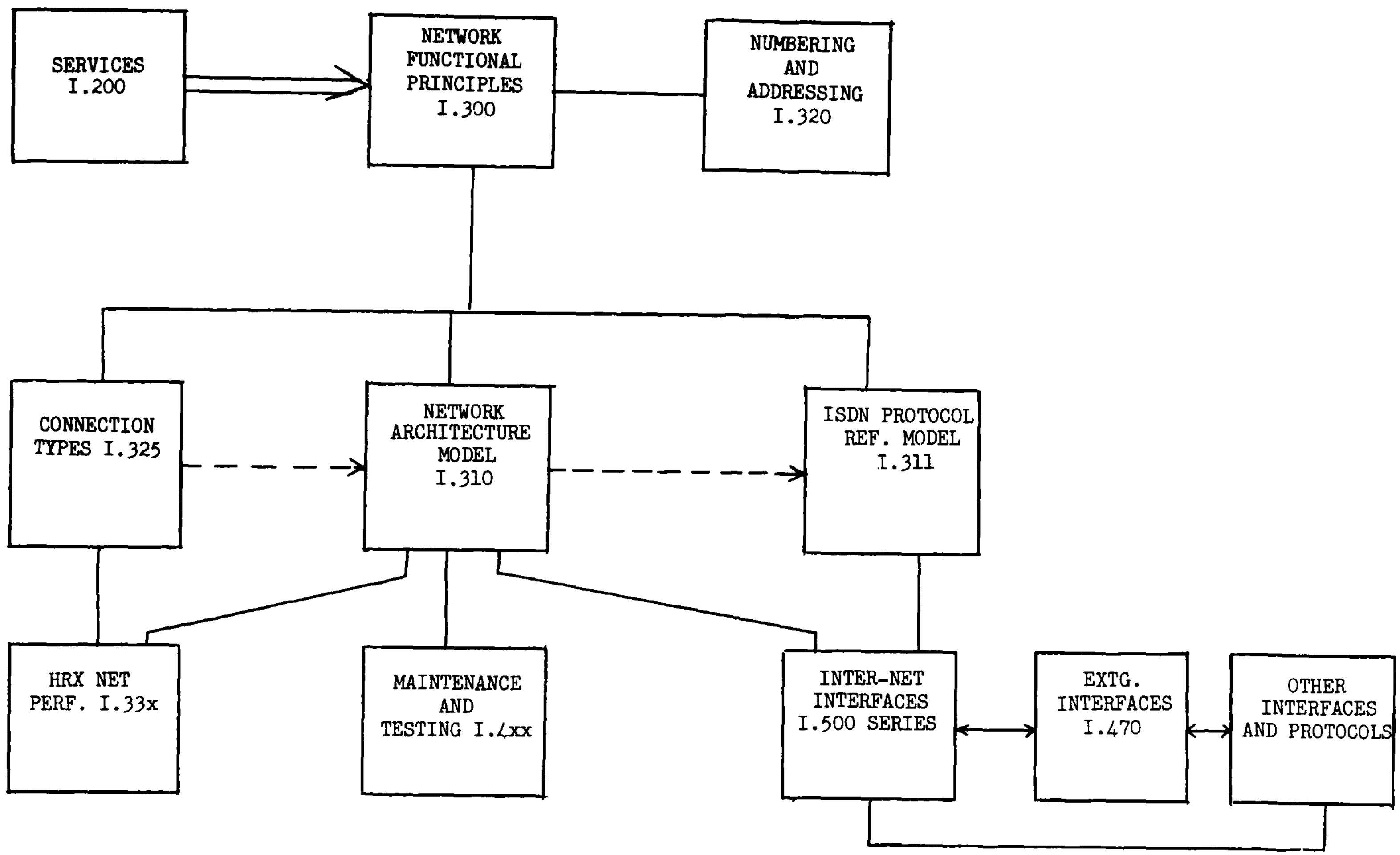


FIGURE 1

ISDN-network series of Recommendations

3. Network functional entities

The design of an ISDN will be evolutionary, adding capabilities in a flexible and modular form. The ISDN may therefore be expected to provide an open-ended set of functional capabilities able to accommodate new needs as they arise at acceptable cost.

To achieve these functional objectives, the ISDN functional description has been designed to :

- define the overall characteristics of the ISDN;
- be implementation independent and place no constraints on national network architectures beyond the network and interface standards given in the I-series of Recommendations;
- take full account of the constraints of existing dedicated networks;
- support the layering concepts defined in X.200.

During a long intermediate period, some features may not be implemented within a given ISDN. Also specific arrangements should be used in order to ensure compatibility with existing networks and services. These features and arrangements are specified within section 5 (Part III) of the I-series of Recommendations. ISDN should also give access to existing services and interwork with existing networks and terminals; in some countries this situation is likely to exist even in a very long term.

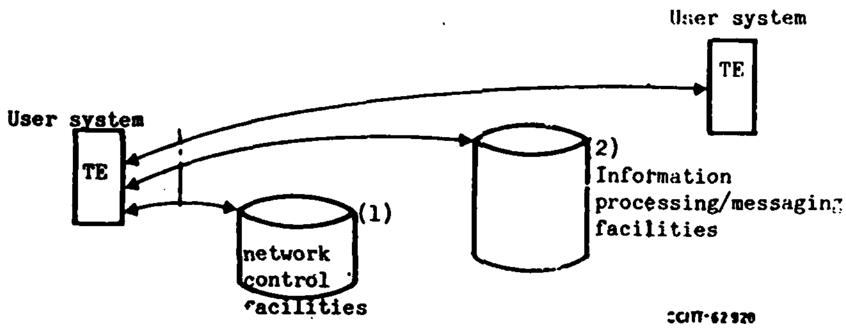
The ISDN network functional entities may be broadly classified into the following groups :

a) Transport functions - comprising :
   - Information transfer functions (connections);
   - Connection control functions;
   - Management and operating functions;
   - Additional lower layer functions;

b) Higher layer functions.

These functional groupings are shown in Figures 2 and 3.

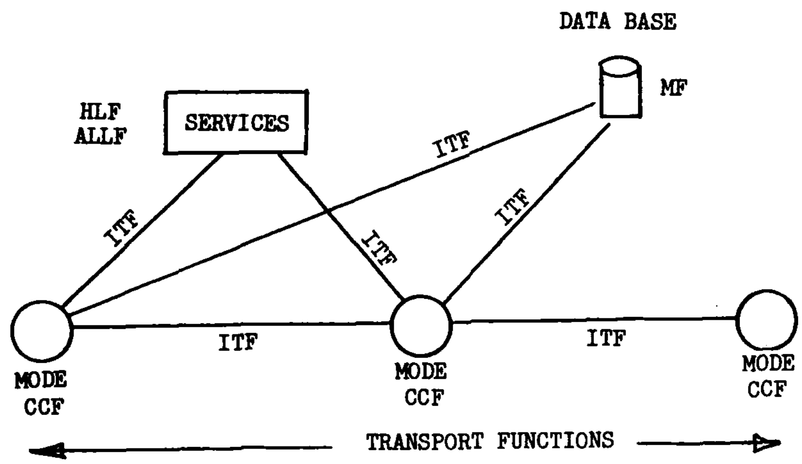
A general classification of ISDN functions into the layers defined in X.200 is shown in Figure 4.



Note (1) Network control facilities perform such functions as, for example, closed user group registration. These are owned by network operators.
(2) Information processing/messaging facilities include data base facilities. These may or may not be owned by network operators.

FIGURE 2

Network functional entities



Notes - CCF = Connection control function
ITF = Information transfer function
MF = Management and operating function
Services functions may be distributed.

FIGURE 3

Network functional entities-schematic

LAYER							
7	APPLICATION - RELATED FUNCTIONS						
6	ENCRYPTION/DECRYPTION	COMPRESSION/EXPANSION	. . .				
5	SESSION CONNECTION ESTABLISHMENT	SESSION CONNECTION RELEASE	SESSION CONNECTION SYNCHRONIZ- ATION	SESSION TO TRANSPORT CONNECTION MAPPING	SESSION MANAGEMENT	. . .	
4	LAYER 4 CONNECTION MULTIPLEXING	LAYER 4 CONNECTION ESTABLISHMENT	LAYER 4 CONNECTION RELEASE	ERROR DETECTION/ RECOVERY	FLOW CONTROL	SEGMENTING/ BLOCKING	. . .
3	ROUTING/ RELAYING	NETWORK CONNECTION ESTABLISHMENT	NETWORK CONNECTION RELEASE	NETWORK CONNECTION MULTIPLEXING	CONGESTION CONTROL	ADDRESSING . . .	
2	DATA LINK CONNECTION ESTABLISHMENT	DATA LINK CONNECTION RELEASE	FLOW CONTROL	ERROR CONTROL	SEQUENCE CONTROL	FRAMING/ SYNCHRONIZATION	. . .
1	PHYSICAL LAYER CONNECTION ACTIVATION	PHYSICAL LAYER CONNECTION DE-ACTIVATION	BIT TRANSMISSION	CHANNEL STRUCTURE MULTIPLEX	. . .		

FIGURE 4

ISDN functions allocated
according to layering principles of X.200

3.1 Transport functional entities

ISDN transport functional entities may be described by the connection requirements, including control, management and performance requirements, between interfaces across an ISDN.

The set of functions which characterize connections in the ISDN is based on the following approach :

a) Given a service request, which is characterized by a set of attribute values, the appropriate connection type(s) to support it must be identified.

Service Request Examination

- Input : Service request = set of attribute values
- Process : Examine service request and determine appropriate network connection type(s)
- Output : Network connection type(s)

b) Once selected, the connection type (which has end-to-end significance) must further be broken down into one or more smaller components called "connection element". For example, a circuit-switched call requiring a database query would imply several connection element such as CCS packet connections and Layer 1 connection through potentially several circuit switches.

Connection element selection

- Input : Connection type
- Process : Determine connection element(s) to implement connection type
- Output : Connection element(s)

c) Each connection element would require a set of network functions in order to be established.

Function Set Determination

- Input : Connection element
- Process : Select appropriate functions to establish connection element
- Output : Set of functions

The association of two network transport entities and the corresponding control functions (including protocols) constitutes a network connection element.

The transport functional entities are shown in Figure 5.

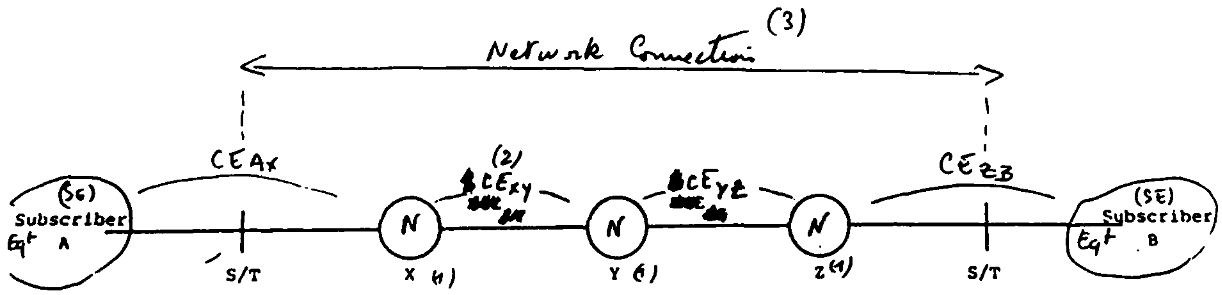


FIGURE 5

2) Protocols associated can be in-band or out-band (see Recommendation I.311).

3) The CE (connection element) used here is a pure functional concept. The relationship between the concepts used in I.3xx (to be introduced in I.3xx) needs further study.

3.2 High layer functional entities

The same principles of classification can be applied in the case where higher layer functions are involved, i.e. in relation with telecommunication services.

The translation of the principles described in section 3 leads to the concept of resp. telecommunication functions and high layer functions.

The high layer functions may be centralized in a special nodes or distributed for example in switching nodes or terminals (refer Figure 7).

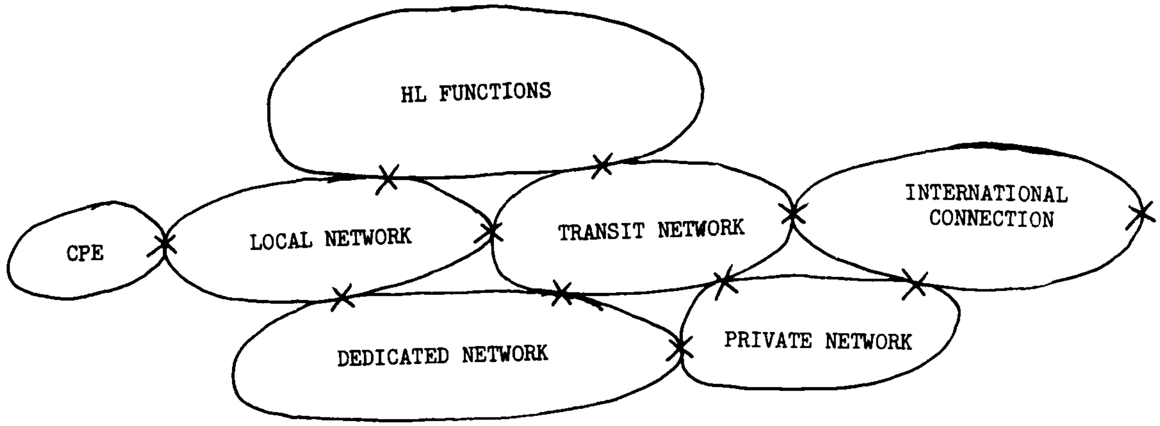
4. Internetwork interfaces

An ISDN may comprise a number of networks, i.e. a network of networks. Typical examples include the interface of national networks to other national or international networks. Similarly the interface of an ISDN is dedicated to networks or private networks.

Additionally, an ISDN may comprise transport and HLF entities. Where some of the ALLF or HLF functions are provided outside the network, further interfaces are identified.

Internetwork interface definitions are necessary for these arrangements for administrative and interworking requirements.

Some typical internetworking interfaces are shown in Figure 6.



X = Potential internetwork interfaces

FIGURE 6

Internetwork interfaces

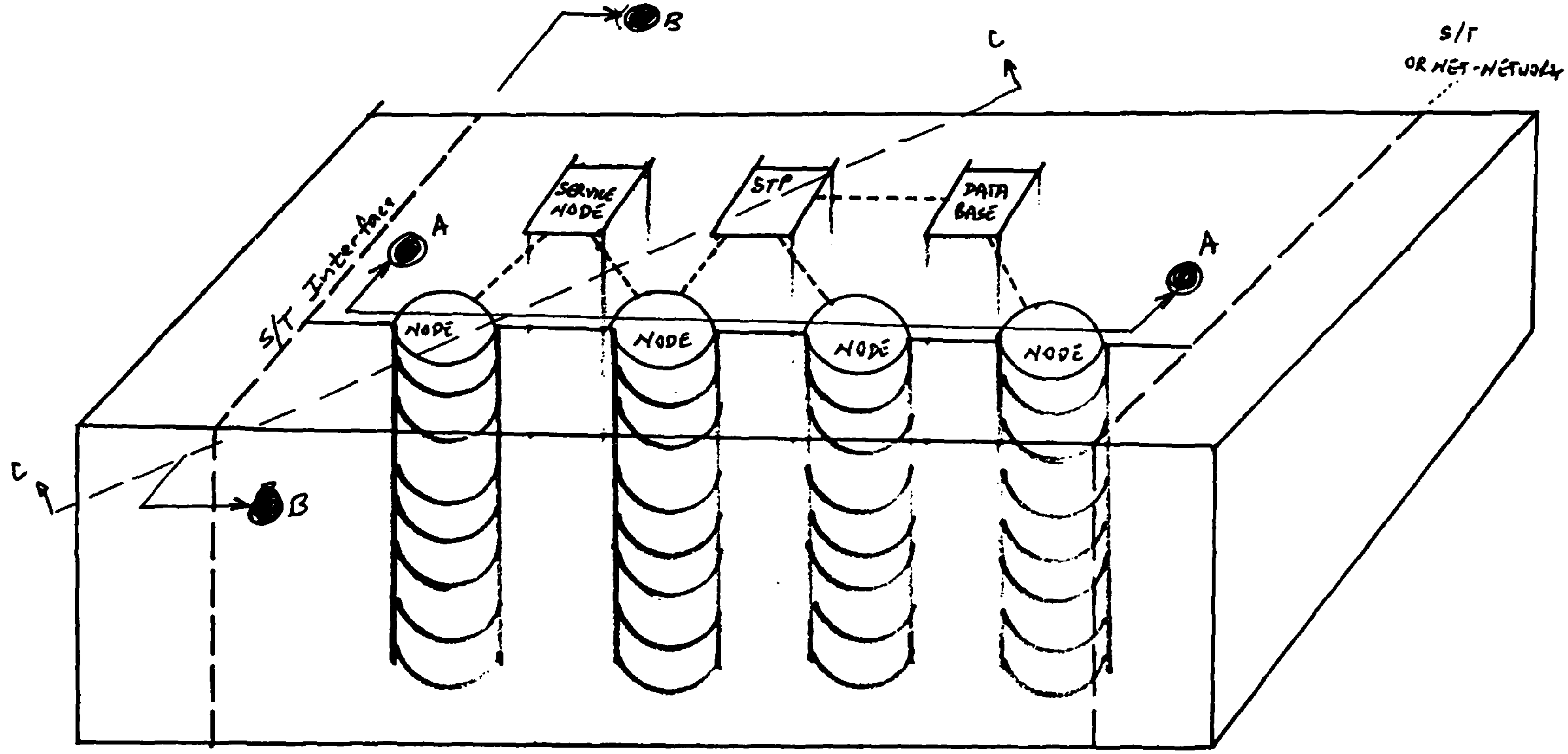


FIGURE 7 - ISDN ARCHITECTURE REPRESENTATIONS.

5. Basic ISDN architecture

A simple ISDN architecture is shown in Figure 7.

The objective of Figure 7 is to provide an introduction to ISDN functional architecture and protocol reference models, and the relationship between network functional entities and network protocols.

Figure 7 viewed from the top describes the network architecture of the model.

Figure 7 viewed from the front describes the protocol configuration between node entities across the network. Taking a longitudinal cross-section, A-A describes the protocol configuration between the network entities intersected.

Taking a cross-section through an interface as for example B-B describes the protocol interactions between layers at that interface.

Figure 7 - to be added.

A.045

CCITT

STUDY GROUP XVIII

Geneva, 21 November - 2 December 1983

Question : 1/XVIII, p.B

Temporary Document 31-E

SOURCE : DRAFTING GROUP ON DRAFT RECOMMENDATION I.310, PART A (FUNCTIONAL MODEL)

TITLE : REPORT OF THE DRAFTING GROUP

1. Documents available

I.310 part A
I.311
I.3xx
Delayed Contribution UV
Delayed Contribution SG
Delayed Contribution SH
Delayed Contribution SI

2. Report of the meeting

The Delayed Contribution UV was examined in detail. New concepts are proposed in this document. In fact it constitutes a complete new text based on an approach different from the existing one in I.310.

Some difficulties were encountered to reach a common understanding in the group.

As a consequence, it was decided to base the discussion on the existing text, the first intention being to improve it with inputs comming from Delayed Contribution UV.

After a detailed examination of the existing text it was decided to adopt a new plan in order to introduce new sections dealing with a more detailed description of the functions used to build the different functional concepts already identified (connections elements).

It is recognized that the terminology used in this Recommendation may need to be aligned with the terminology used in other Recommendations.

3. Plan proposed

A new text giving the general objectives of this Recommendation.

1. Introduction

A diagram showing the relationship between the different I.3.. Recommendations was introduced.

2. Connection elements and functions

2.1 General 2.2 Function set determination 2.3 Super set of functions	based on existing text

3. Classification of functions

New section.

4. Network functional entity

New section.

5. Application connection

New section.

4. New text

The new text is given in an Annex to this document.

The work done should be used as a framework for the drafting and editorial comments taking into account the work of the Connection Group and protocols.

Functions of ISDN

This recommendation applies to ISDN's as defined by the I series recommendations. The concepts introduced in this recommendation are based on I.120, where the ISDN concept is described and defined and I.200 which describes services that are supported by an ISDN.

The objective of this recommendation is to provide a common understanding and a description of ISDN capabilities. Consequently it constitutes the basis for the introduction of I.3.. recommendations (I.3XX, I.311 etc.).

This recommendation is structured as follows:

1) An introduction gives the basic principles used to describe the ISDN capabilities and the relationship with other recommendations.

2) A functional description principle of ISDN capabilities (Part A).

3) An architectural description (part B, text for further study).

The principles described in this Recommendation are not intended to preclude or inhibit any implementation of ISDN.

1. Introduction

ISDN is defined as a network consisting of a limited set of network connection types and possibly additional functions in order to support a wide range of bearer or telecommunication services and possible supplementing services (facilities). ISDN capabilities are described in various I-series Recommendations. Figure 1 shows one possible grouping and the relationships between some of these Recommendations.

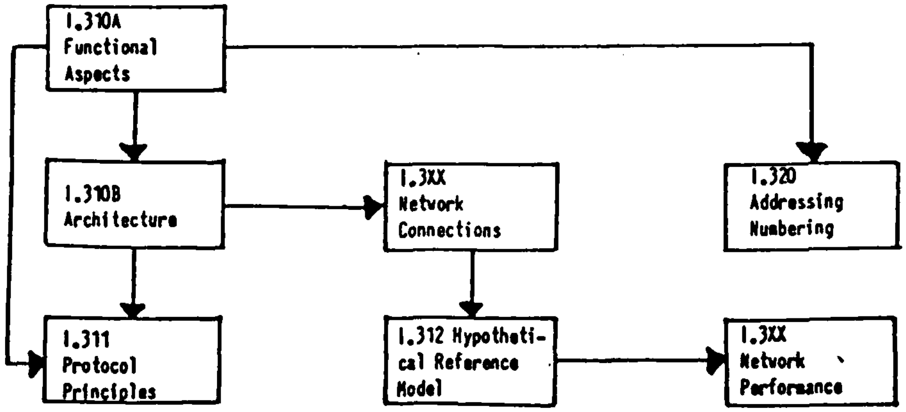


FIGURE 1

2. Connections, connection elements and functions

ISDN capabilities need to be described in such a way that takes account of the fact that an ISDN will be required to support new services and supplementary services as the need arises.

In order to achieve this requirement the functional classification outlined is intended to be as flexible as possible and provides a framework of concepts which :

1) are implementation independent;

2) allow for the constraints of existing networks;

3) cover all aspects of ISDN functions;

4) is in line with OSI RM philosophy (layering).

In order to achieve these requirements the approach used in the Recommendation is to identify as the smallest functional unit of the ISDN functional architecture network functions and to use combinations of these functions to build network connections as described in I.3xx and additional low layer functions (ALLF) and higher layer functions (HLF) which support supplementary services/facilities. In I.3xx describing ISDN network connection types, smaller units of connection have been identified called connection elements and these can also be described in terms of set of network functions.

2.1 Function set determination

A network connection type can be defined by a set of functions characterizing the ISDN capability to provide suitable means for the transplex of data between two interfaces.

The determination of the appropriate set of functions is based on a three step approach :

i) Given a service request, which is characterized by a set of attribute values, the appropriate connection type(s) to support it must be identified.

Service Request Examination

- Input : Service request = set of attribute values
- Process : Examine service request and determine appropriate network connection type(s)
- Output : Network connection type(s)

ii) Once selected, the connection type (which has end-to-end significance) must further be broken down into one or more smaller components called "connection element".

Connection element selection

- Input : Connection type
- Process : Determine connection element(s) to implement connection type
- Output : Connection element(s)

iii) Each connection element would require a set of network functions in order to be established.

Function Set Determination

- Input : Connection element
- Process : Select appropriate functions to establish connection element
- Output : Set of functions

2.2 Superset of functions

The functions mentioned above belong to a superset of functions which may be called upon from time to time by the network in order to support a wide range of services and facilities (bearer service, telecommunications services, interworking situations between services, etc.). This superset is illustrated in Figure 2, in which the functions are structured in a form corresponding to the seven layers of the OSI model.

LAYER								
7	APPLICATION - RELATED FUNCTIONS							
6	ENCRYPTION/DECRYPTION	COMPRESSION/EXPANSION	. . .					
5	SESSION CONNECTION ESTABLISHMENT	SESSION CONNECTION RELEASE	SESSION CONNECTION SYNCHRONIZ-ATION	SESSION TO TRANSPORT CONNECTION MAPPING	SESSION MANAGEMENT	. . .		
4	~~ADDRESSING~~	TRANSPORT CONNECTION MULTIPLEXING	TRANSPORT CONNECTION ESTABLISHMENT	TRANSPORT CONNECTION RELEASE	ERROR DETECTION/ RECOVERY	FLOW CONTROL	SEGMENTING/ BLOCKING	. . .
3	ROUTING/ RELAYING	NETWORK CONNECTION ESTABLISHMENT	NETWORK CONNECTION RELEASE	NETWORK CONNECTION MULTIPLEXING	CONGESTION CONTROL	Addressing . . .		
2	DATA LINK CONNECTION ESTABLISHMENT	DATA LINK CONNECTION RELEASE	FLOW CONTROL	ERROR CONTROL	SEQUENCE CONTROL	FRAMING/ SYNCHRONIZATION	. . .	
1	PHYSICAL LAYER CONNECTION ACTIVATION	PHYSICAL LAYER CONNECTION DE-ACTIVATION	BIT TRANSMISSION	Channel Structure Multiplex	. . .			

FIGURE 2

Superset of functions

3. Classification of functions

The functions are classified in two classes, the lower layer functions (LLF) corresponding to layers 1 to 3 of the OSI model and the higher layer functions corresponding to layers 4 to 7 (HLF) (see Figure 3).

7 HLF 4
3 LLF 1

FIGURE 3

Lower layer functions are sub-divided into two categories :

i) the bearer functions (BF) supporting the connection elements;

ii) the additional lower layer functions (ALLF) supporting additional services (e.g. facilities).

The bearer functions correspond to :

- Call control functions
  - Connection handling
  - Connection routing

- management and operating functions

- data transfer functions (multiplexing, segmenting and blocking, sequencing etc., .. Refer to X.200)

4. Network functional entity (or functional grouping)

A network functional entity is defined as being a set lower layer functions relating to a connection element. The association of two network functional entities and the corresponding peer protocols constitutes the connection element (Figure 4). As a consequence, a connection element is delimited by protocol breakpoints (generally at level 3).

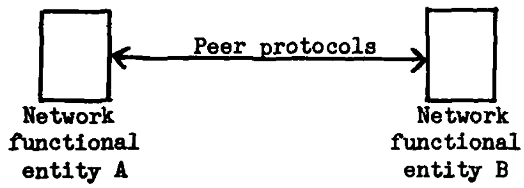


FIGURE 4

Connection element

Depending on implementation considerations, a network functional entity can be built with :

- bearer functions only;

- bearer functions and additional lower layer functions.

During a long intermediate period, some functions may not be implemented within a given ISDN. Also specific arrangements should be used in order to ensure compatibility with existing networks and services. These features and arrangements are specified within section 5 (part III) of the I-series of Recommendations. ISDN should also give access to existing services and interwork with existing networks and terminals; in some countries this situation is likely to exist even in a very long term.

The use of the different concepts introduced above in the construction of a network connection type is shown in Figure 5.

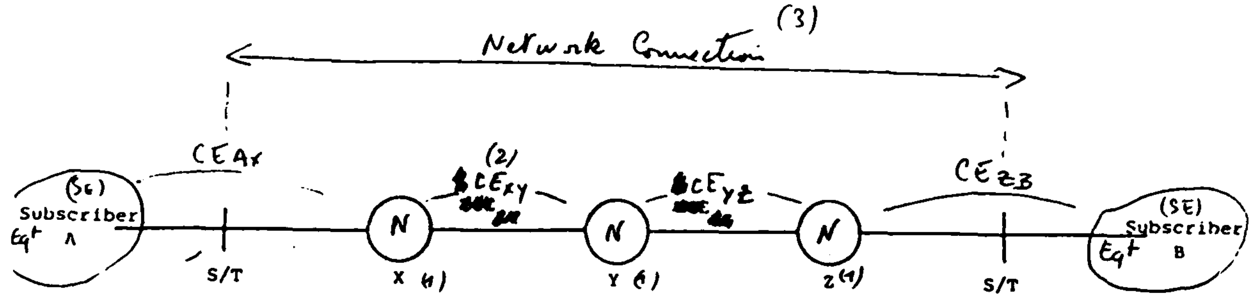


FIGURE 5

1) Each node X, Y or Z contains two network functional entities and a protocol breakpoint.
2) Protocols associated can be in-band or out-band (see Recommendation I.311).
3) The CE used here is a pure functional concept. The relationship between the concepts used in I.3xx (to be introduced in I.3xx) needs further study.

5. High layer functions

5.1 Classification

The same principles can be applied in the case where higher layer functions are involved - i.e., in relation with telecommunication services.

The translation of the principles described in section 3 leads to the concept of resp. telecommunication functions and additional high layer functions.

These high layer functions are implemented in specialized dedicated service entities and in the terminals.

The specialized dedicated service entities can be centralized in special nodes or distributed for examples in switching nodes.

5.2 Application connection

Application connections are supported by network connections and cannot be associated to a unique connection element.

In the simplest case a unique network connection support the application connection (telecommunication service between two terminals).

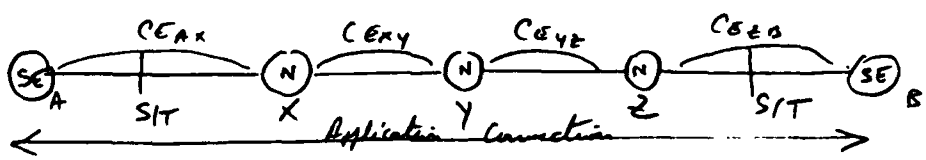
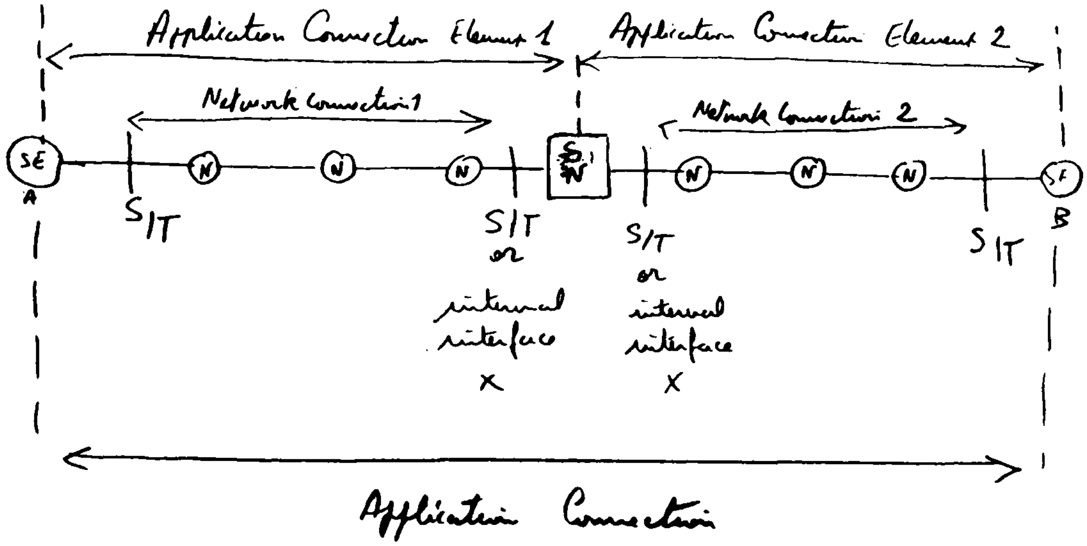


FIGURE 6

Application connection in the case of a telec unication service

In more complex situations (Special Node) several network connections are used to support an application connection. It is assumed that an application connection element is associated to each network connection as they can be associated to high level protocol breakpoint.

Figure 7 shows an example of a possible association of two application connection elements in a unique application connection.



SP : Special Node (e.g. Interworking unit using level 7 functions)

FIGURE 7

Application connection elements

CCITT
STUDY GROUP XVIII
Geneva, 21.11 - 2.12.1983

Temporary Document No. 33-E

Question 1B/XVIII

SOURCE : DRAFTING GROUP _ I.311

TITLE : DRAFT RECOMMENDATION I.311

ISDN PROTOCOL REFERENCE MODEL

1. Introduction

1.1 General

The objective of the ISDN protocol reference model is to model information flows, including user information and control information flows, to and through an ISDN. It is based on the principles given in the X.200 series of Recommendations.

It is not intended as a definition of any specific implementation of an ISDN or of any systems or equipment in, or connected to, an ISDN.

Examples of applications of this model are included in this Recommendation.

1.2 Structure of the Recommendation

The ISDN protocol reference model is structured according to the following:

i. information flows;

ii. network functional entities - which are described in Rec. I.300 and which describe the location of interfaces in the ISDN;

iii. protocol reference configurations - which describe the protocol interactions between interfaces;

iv. interface protocol structures - which describe the layer relationships at each interface;

v. examples of the application of the model to selected ISDN connections.

1.3 Information Flows

The protocol reference configurations and interface protocol structures provide a means of modeling the information flows between:

- two ISDN users;
- an ISDN user and a functional entity within an ISDN, e.g. network control facilities;
- an ISDN user and a functional entity inside or outside an ISDN, e.g. an information storage/processing/messaging facility;
- various functional entities in an ISDN;
- an ISDN and other networks.

1.4 Relation with Recommendation X.200

The protocol reference model, interface structures and protocol reference configurations are defined by layered structures based on and using the terminology of the Reference Model for Open Systems Interconnection (OSI) for CCITT Applications (draft Recommendation X.200 (Revised)). The layer identification used in Recommendation X.200 is limited in this Recommendation to the use of layer numbers. Layer titles (eg network layer) as used in Recommendation X.200 are sometimes misleading in the ISDN context, and have not been used here.

Some of the information flows descibed above are considered to be outside the current scope of Recommendation X.200 (A below), or have not yet been explicitly modelled by Recommendation X.200 (B below). Examples of A include:

* Information flows for out-of-band call control process, or more generally, information flows among multiple related protocols;
* information flows for selection of connection characteristics;
* information flows for renegotiation of connection characteristics for calls;
* information flows for suspension of connections;
* information flows for overlap sending;
* in general, information flows for multi-media calls.

Examples of B include:

* application to other than end-systems, e.g. signal transfer points (STPs) and inter-networking points:

* information flows for multi-point connections;

* information flows not included in X.200 considerations such as:

  - voices (including A/U law conversions)

  - video

  - transparent

  - telex.

One objective of this Recommendation includes an examination and resolution of these issues. Depending on the resolution, it is a matter for further study whether the ISDN Protocol reference model remains a separate Recommendation or whether the concepts contained in this Recommendation should be incorporated in a redraft of the X.200 series of Recommendations.

1.5 Relation with the Q-series of Recommendations

The functions and procedures described in the Q-series of recommendations for access and network signalling in general conform to the principles described in this Recommendation. Certain features, however, in particular facility procedures, user-user signalling, may require further study to determine the most appropriate method of modelling.

2. Modelling Concepts

2.1 Information Flows

The information flows described in section 1.3 can be classified into the two following categories:

1) user information - for example, digitized voice, data and other information transmitted between users. This information may

be transmitted transparently through the ISDN, or it may be processed or manipulated. Examples of the latter include data which is stored and encrypted within the network;

ii control - this is information which is acted upon in:

*controlling a network connection (such as establishing and clearing down);

* controlling the use of an already established network connection (e.g. change of service characteristics during a call such as alternate voice/data);

* providing both above control functions (as in a multipoint conference call with service change).

These information flows are illustrated in Figure 1.

2.2 Protocol Systems

In order to construct the ISDN protocol reference model, a fundamental generic protocol block has been identified. Such a protocol block can be used to describe various elements in the ISDN user premises and the network (eg terminal equipment (TE), network termination (NT), exchange termination (ET), signalling point (SP) and signalling transfer point (STP), etc.).

Figure 2 illustrates the conceptual aspects of the protocol block. A three dimensional representation is used to describe three types of information systems, namely:

- U information system
- C information system
- M information system

* U information system - represents those functions and procedures which are used to convey information between user entities;

* C information system - represents generically those functions which are used to establish, sustain, clear and manage connections;

* M information systems - represent generically all local (e.g. terminal) management aspects associated with the transfer of user information and control information. Examples of these functions include the selection of appropriate responses to connection failure and other exception conditions occurring over the communication facility. These functions also include "network management" and traffic control to optimize utilization of network resources.

3. External interactions of a protocol block

External interactions at the lower and upper faces of a protocol block are illustrated in Figure 2:

- Physical transfer of information (whether transport or control) between one protocol block and another takes place over the physical media attached to both ~~F~~ U and C information systems. In some applications (e.g., ISDN basic access), a common physical medium may be shared by both ~~F~~ U and C systems.
- Interactions at the upper face of the protocol block to various application processes external to the block. These include applications control applications, etc.

The details of these external interactions are not part of the ISDN protocol refernce model. They may however be the subject of other CCITT Recommendations.

4. Interface protocol structures

Protocols and procedures used at the boundary of an ISDN or across an interface within an ISDN are described in terms of a seven-layer structure based on Recommendation X.200. As described in section 2.1 the ISDN network architecture is such that generally there are two planes of communication between communicating entities, namely:

- the user transport plane (or U plane) accomodating user transport information:
- the control plane (or C plane) accomodating control information.

The dialogue in each plane is independently described in terms of a separate seven layer structure, corresponding to the structure of the U protocol block and C protocol block described in §2.

In some applications, some of the layers in either protocol structure may be null, and some layer boundaries may be considered to exist only conceptually, with no boundary functions (primitives) defined. Layers, layer services and layer protocols will be defined only when necessary.

The seven layers of the protocol structures represent seven distinct ordered partitions. Each layer exhibits specific properties and features in respect of their relationship both with adjacent layers and with more general aspects of communications. Each layer offers a specific layer service or set of layer services to the layer above. The functions of each layer and the service provided by each layer are defined in general terms in Recommendation X.200. Detailed specification of layer services and protocols are the subject of other Recommendations.

5. ISDN PROTOCOL REFERENCE MODEL

From the fundamental modelling concepts described in Section 2, an ISDN Protocol Reference Model has been developed as illustrated in Figure 3. From the standpoint of modelling the various network elements such as network control facilities, information processing/messaging facilities as shown in Figure 1 can be treated in the same manner as a user system such as a terminal equipment (TE).

The access between the customer equipment and the network is represented by the S/T reference plane (cf. S/T reference point in the ISDN user/Network Reference Configuration as described in Draft Rec. I.411.

For network elements such as exchanges, signalling points (SP), signalling transfer points (STP), a mirror image version of the fundamental building block is used. This representation allows peer-to-peer protocols inside the network as well as ISDN User/Network access to be taken into account. Note however, for clarity these peer-to-peer protocols are not shown in Figure 3.

6. EXAMPLES OF APPLICATIONS OF THE ISDN PROTOCOL REFERENCE MODEL

From the fundamental modelling concepts described in section 2, ISDN Protocol configurations have been developed using the generic protocol reference model described in section 5. From the viewpoint of modelling the various network elements (such as network control facilities, network data bases, information processing/messaging facilities) can be treated in the same manner as an end system such as a terminal equipment (TE).

Figures 4 to 12 illustrate applications of the protocol reference model to various ISDN connections.

7. EXAMPLES OF APPLICATIONS OF THE PROTOCOL REFERENCE MODEL TO NETWORK FUNCTIONAL ENTITIES

Figure 13 illustrates a model representing information flows and associated logical blocks for the communication process in terminal equipment (TE).

For network elements such as exchanges, signalling points (SP), signalling transfer points (STP), a mirror image version of the protocol modellling block is used. This representation allows peer-to-peer protocols inside the network as well as ISDN user access to be taken into account. An example of such a model is shown in Figure 14.

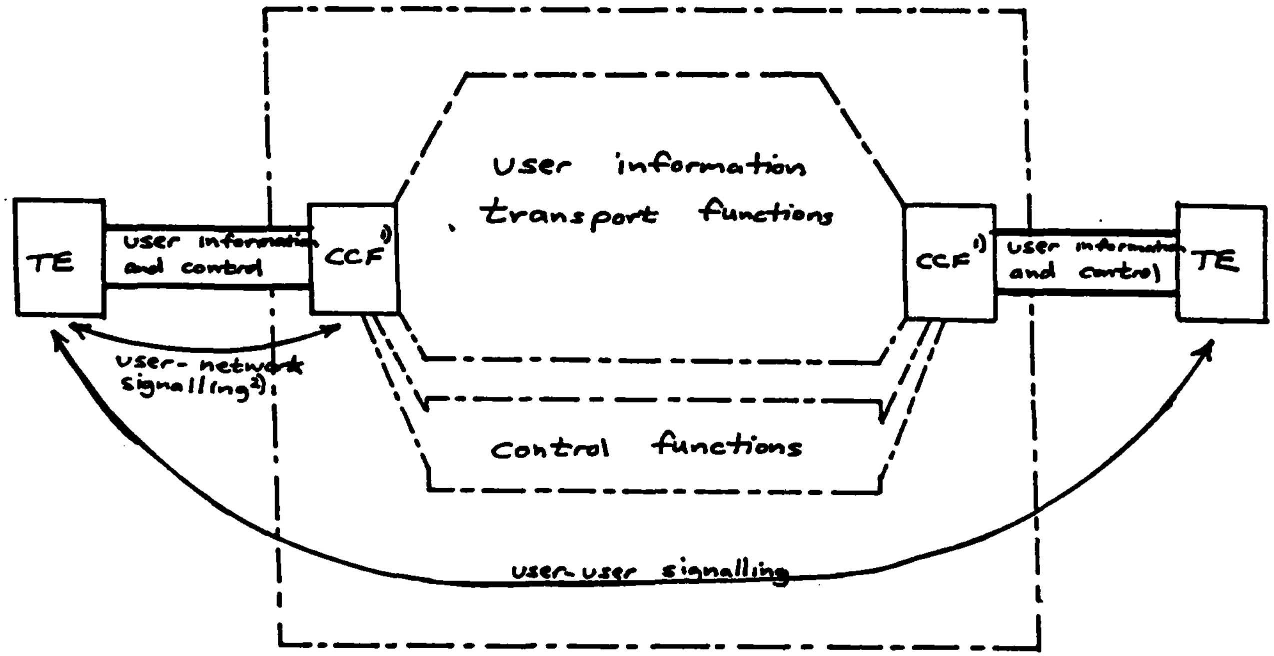


Figure 1: Information Flows

1) CCF: Connection Control Function (Ref. I.300)

2) Includes connection control and ~~signal~~ communication with e.g. operations centre's

Table 1 shows four different types and their functions.

TABLE 1

S-plane information categories (1)

Note: A particular application may use any combination of S_1, S_2 and S_3.

TYPE	FUNCTION		APPLICATIONS	ILLUSTRATION
S_1	User-to-network in-band signalling		Establishment, flow control and clear down of S information type at layer 3	Figure 7
S_2	User-to-network common channel signalling		- Call set up and release of B-channel - Other uses are for further study (e.g. call set-up for P-type of information in multimedia calls)	Figure 6
S_3	User-to-user signalling	S_{3A}	- TE to TE signalling - PABX to PABX signalling	Figure 8
		S_{3B}	- TE to HLF (2) signalling - TE to network data base signalling	
S_4	User-to-operations centre signalling		- TE to local exchange signalling for operation and maintenance (Note 3)	Figure 9 (Note 3)

Note 1: Internal network signalling and its relationship to above categories is not dealt with in this Recommendation.

Note 2: HLF may reside inside or outside the network.

Note 3: Figure 9 shows the operations centre reached via the local exchange.

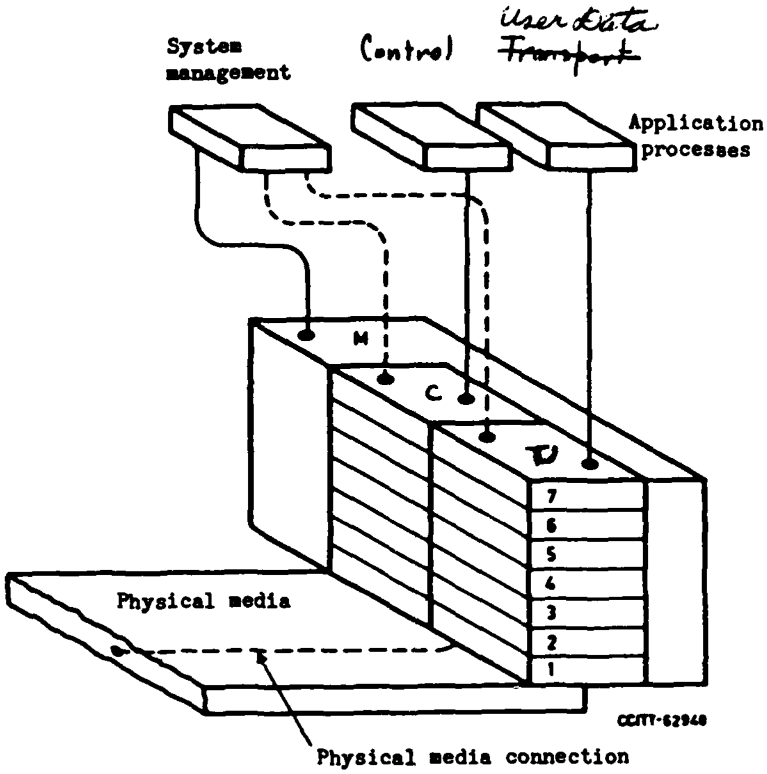
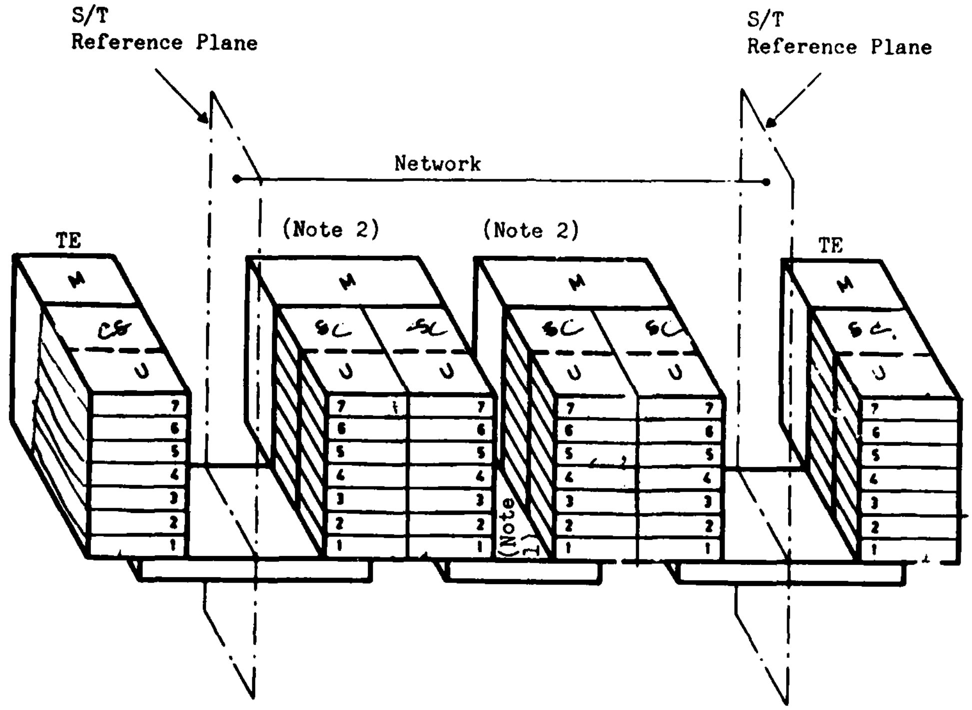


Figure 2 - External interactions associated with a fundamental building block



Note 1: Within the network, different physical media connections may be used between fundamental building blocks (e.g. exchanges, Signalling Points, Signalling Transfer Points.)

Note 2: For network elements that perform relaying functions (such as switching exchanges, signalling transfer points), the U information functional grouping is represented by the lower three layers only. For network elements that perform end-systems functions (such as those providing information processing/messaging facilities), all the seven layers are represented.

Figure 3a- ISDN protocol reference model
(3-dimensional representation)

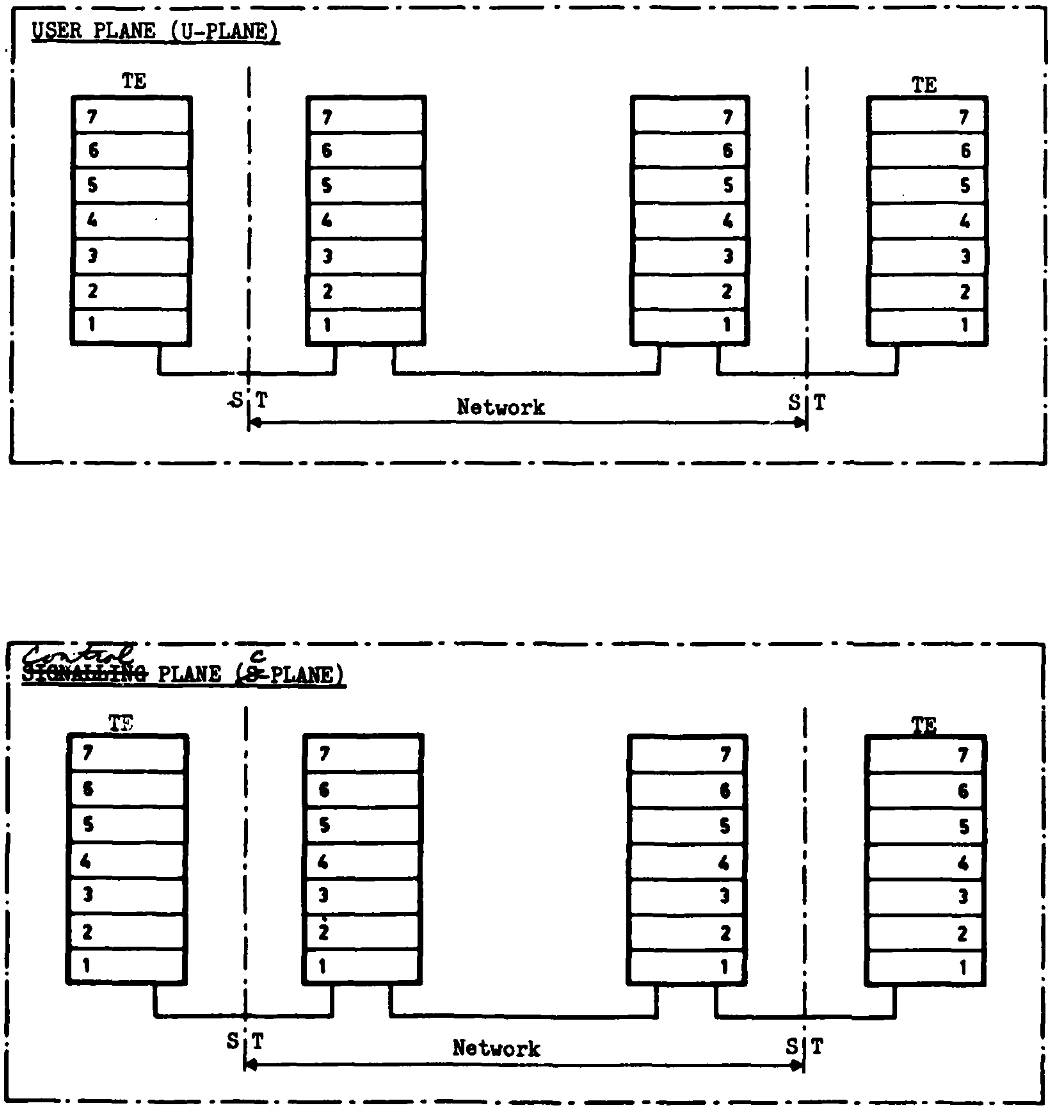


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Figure ~~[illegible]~~ 3b - ISDN protocol reference model
(two-dimensional representation)

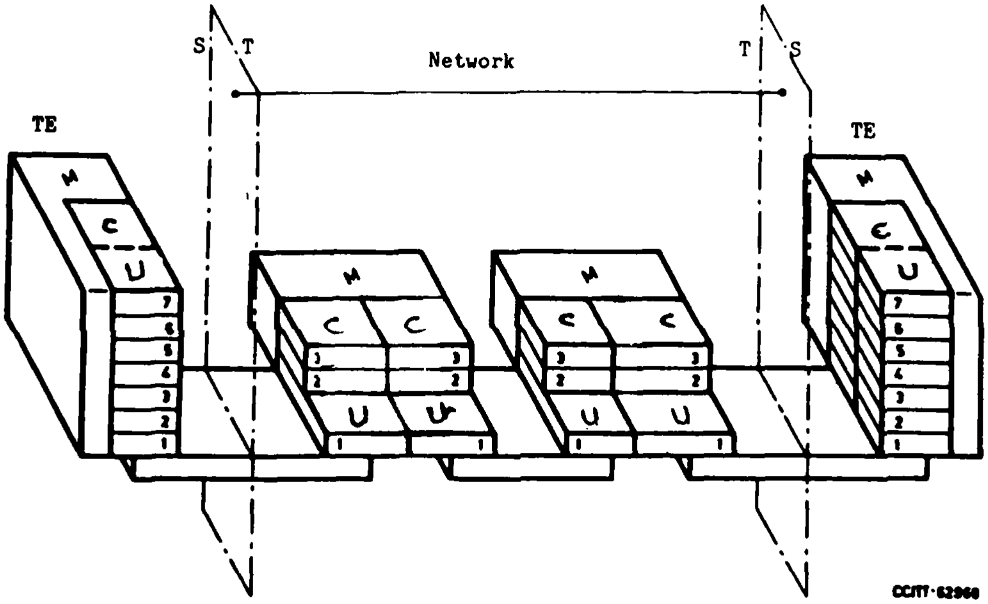

Figure 4a - ISDN protocol reference configuration for circuit-switched connection (three-layer approach used)

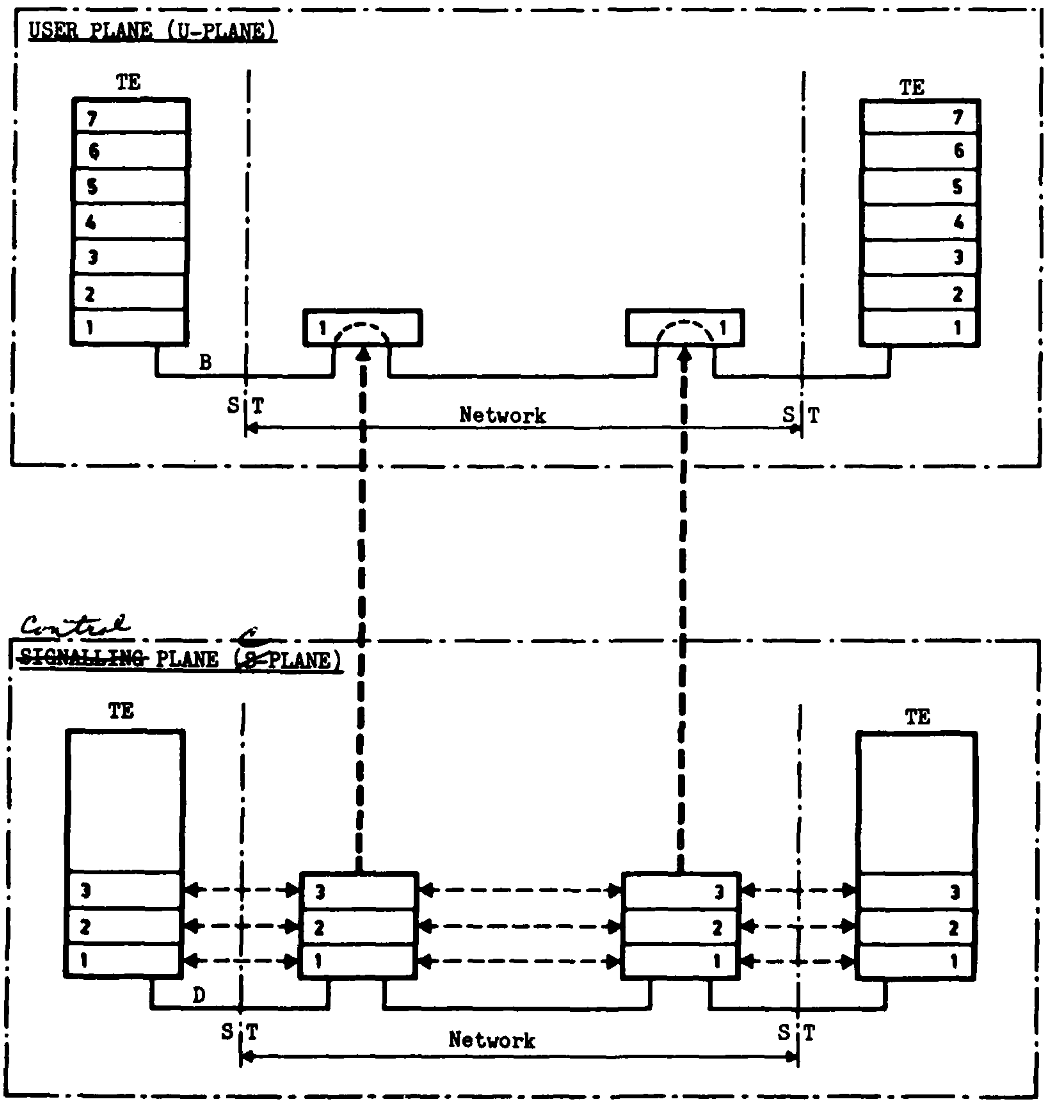

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Figure ~~4~~ - Application to common channel circuit-switched connection
(2-dimensional representation)

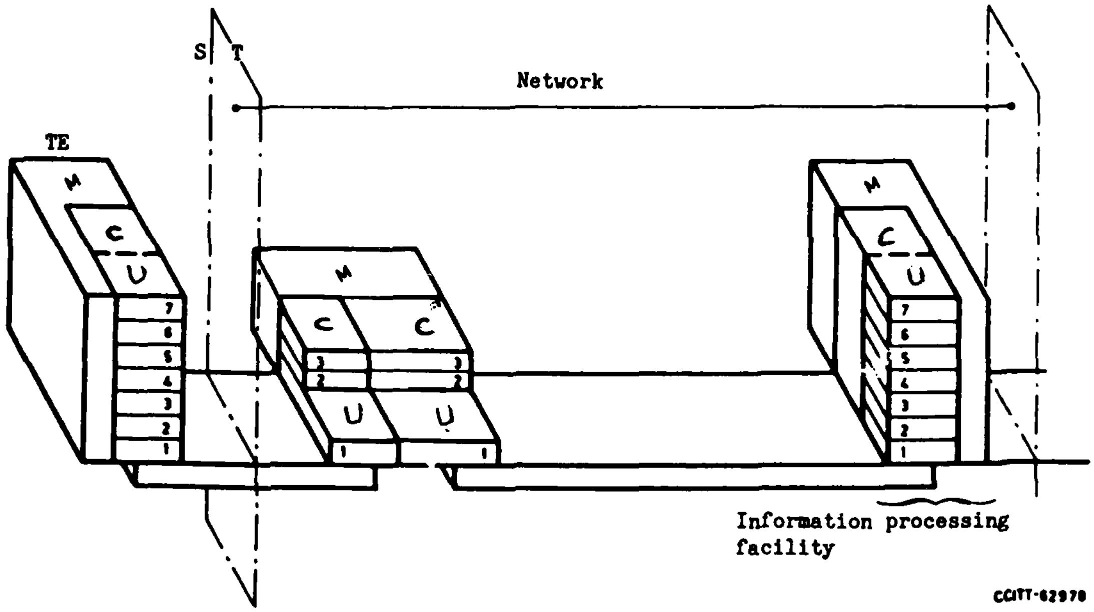

Figure 5a - ISDN protocol reference configuration for circuit-switched access to higher level functions (three-layer approach used)

(2418)

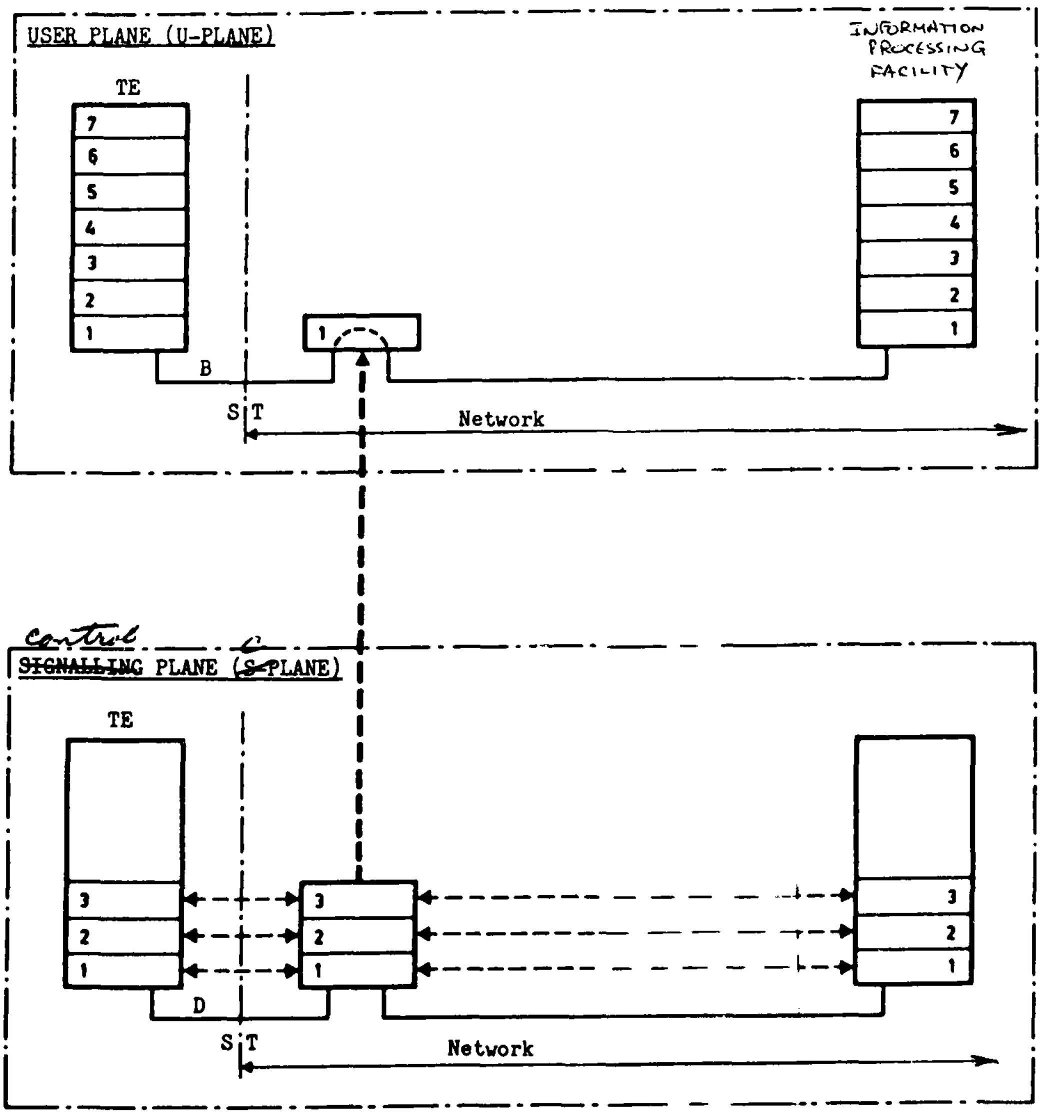

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Figure [illegible] - Application to common channel circuit-switched connection access to higher layer functions (2-dimensional representation)

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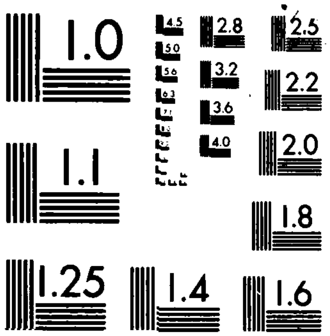

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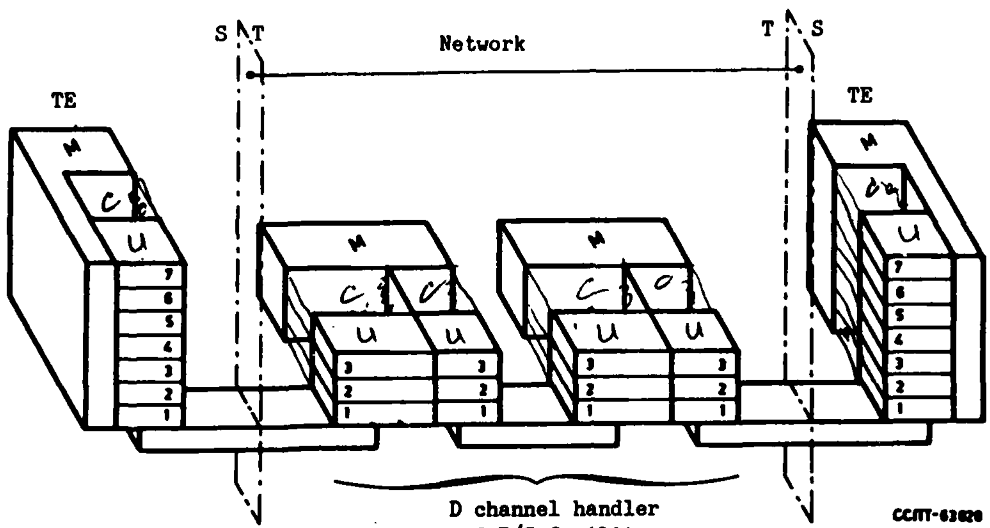

Figure 6a - ISDN protocol reference configuration for packet-switched connection via D channel (three-layer approach used)

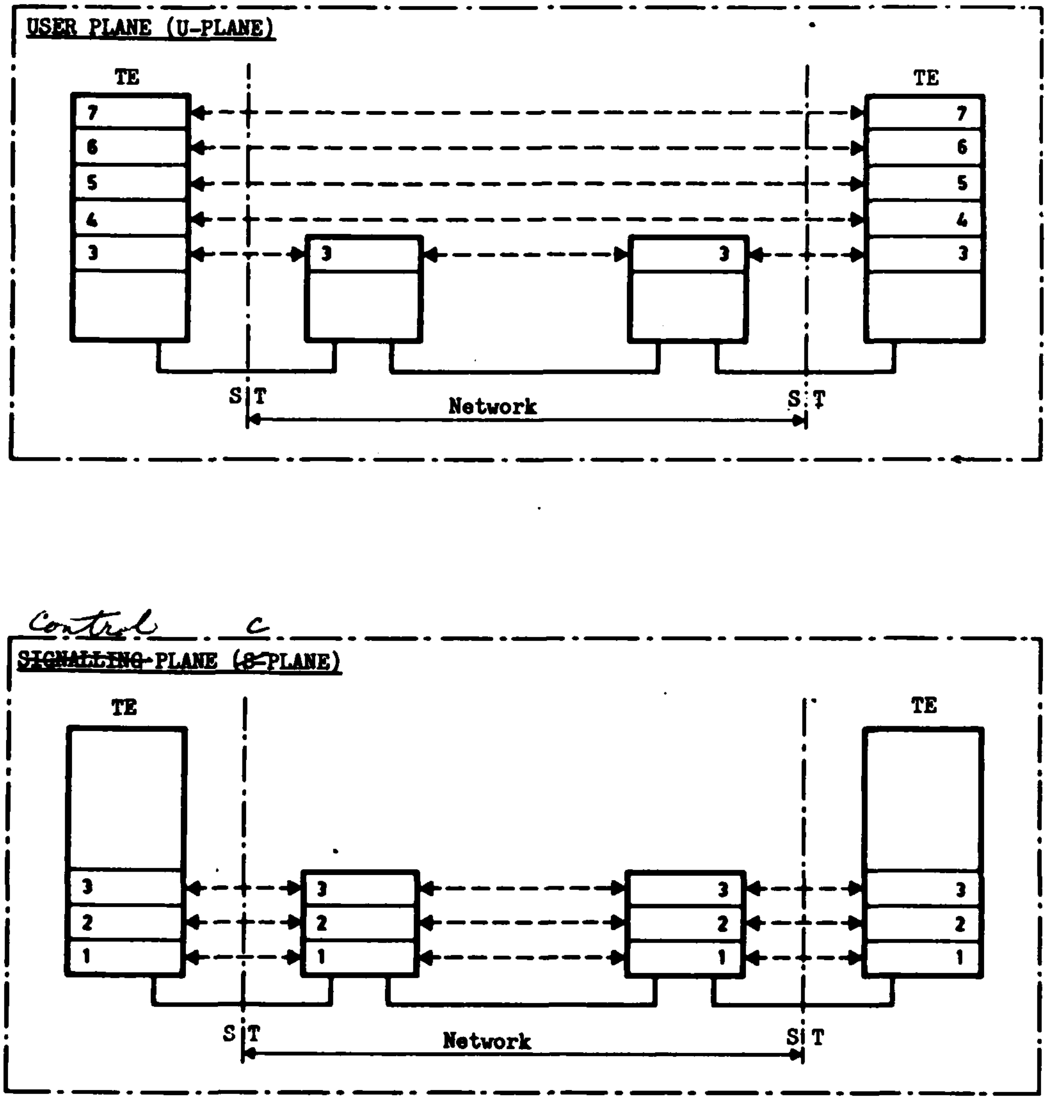

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Figure 3 - Application to packet switched connection via D-channel in the ISDN (illustration of S_1)

(2418)

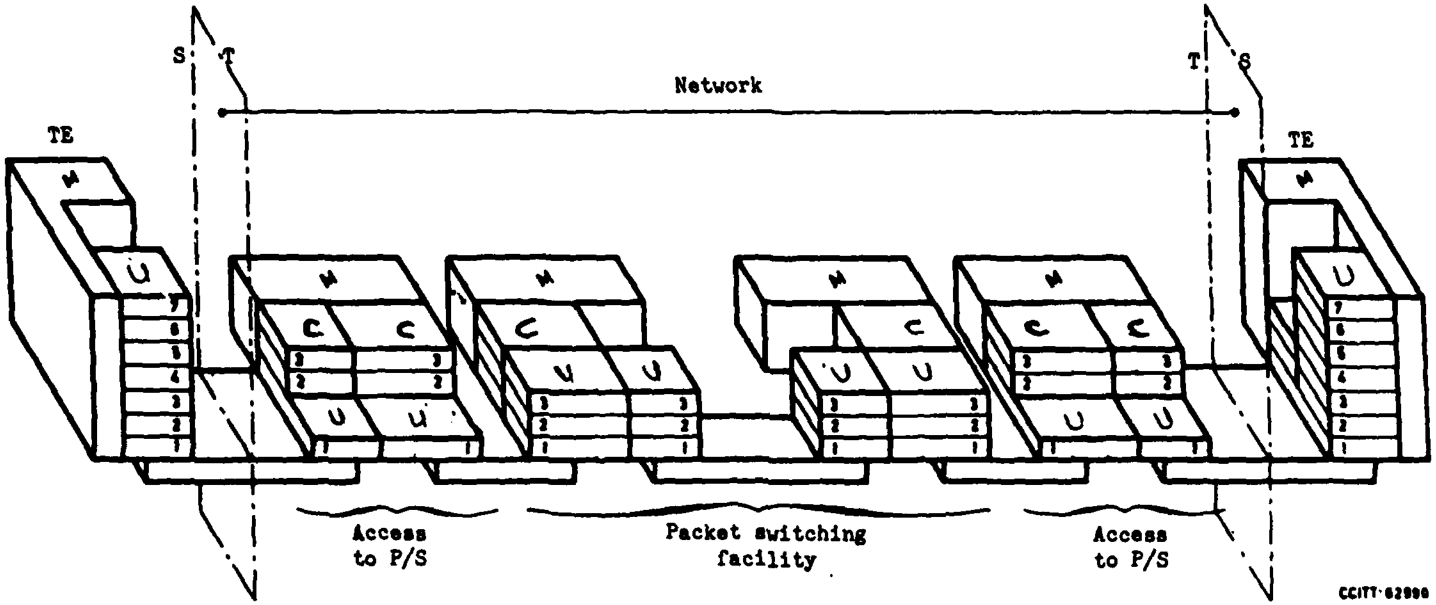

Figure 7a - ISDN protocol reference configuration (basic connection - P/S via B channel) for packet-switched connection via B channel (three-layer structure used).

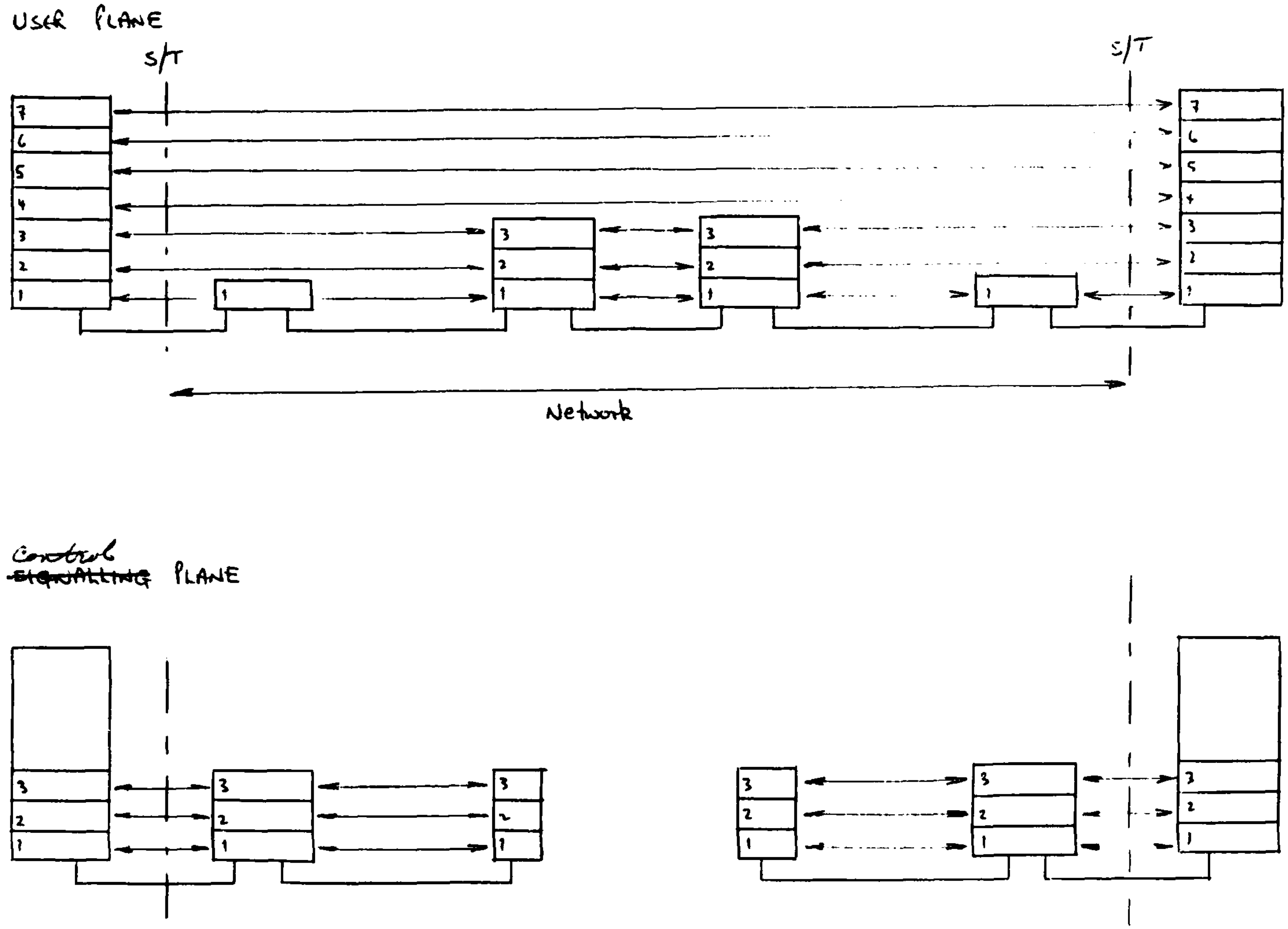

Figure 7b – Application for packet-switched connection via B-channel

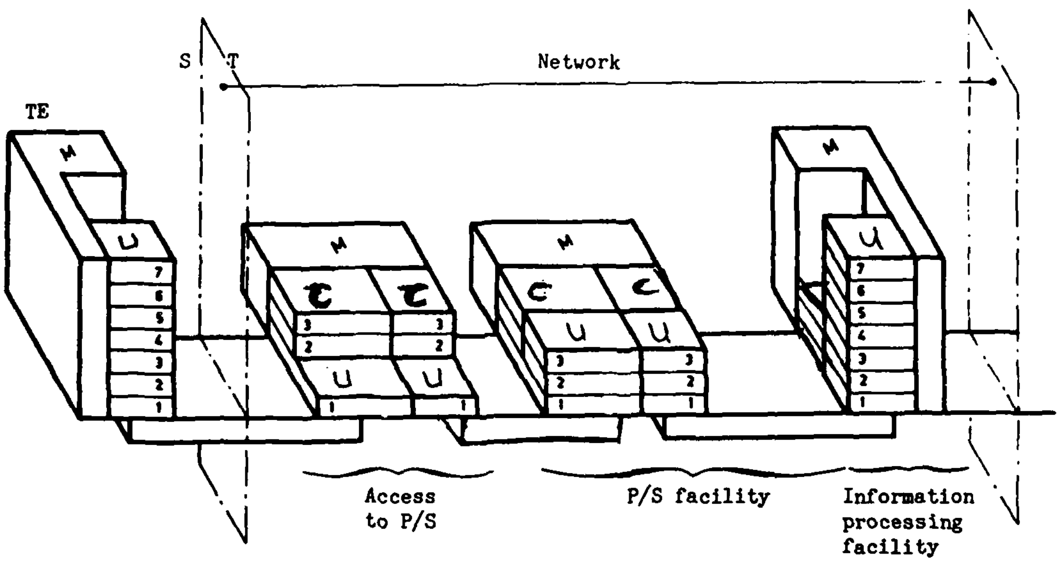

Figure 8 - ISDN protocol reference configuration (access to HLF - P/S via B channel) for packet-switched access to higher layer functions via B channel (three-layer structure used)

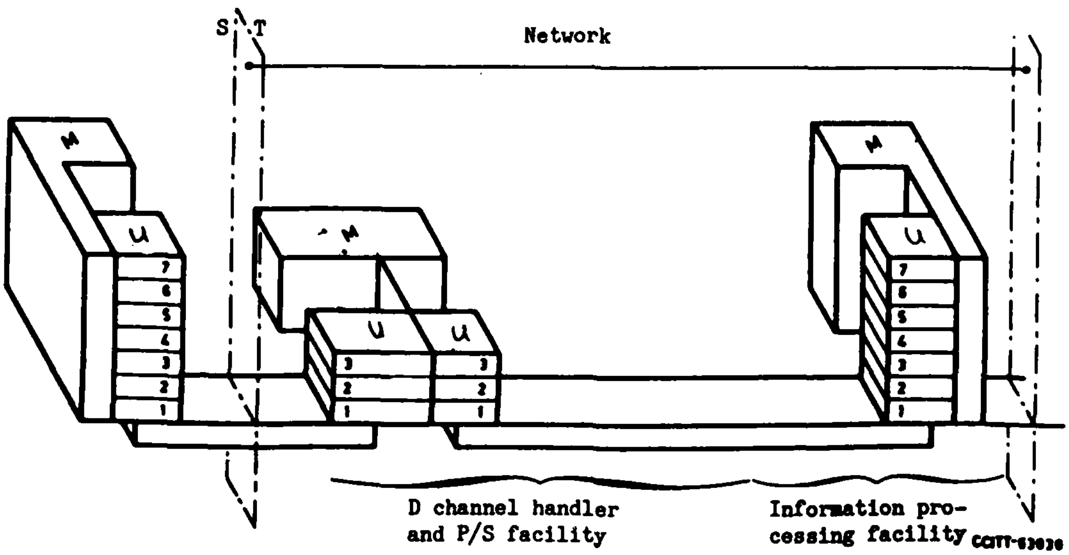

Figure 9 - ISDN protocol reference configuration for packet-switched access to higher layer functions via D channel (three-layer approach used)

(2418)

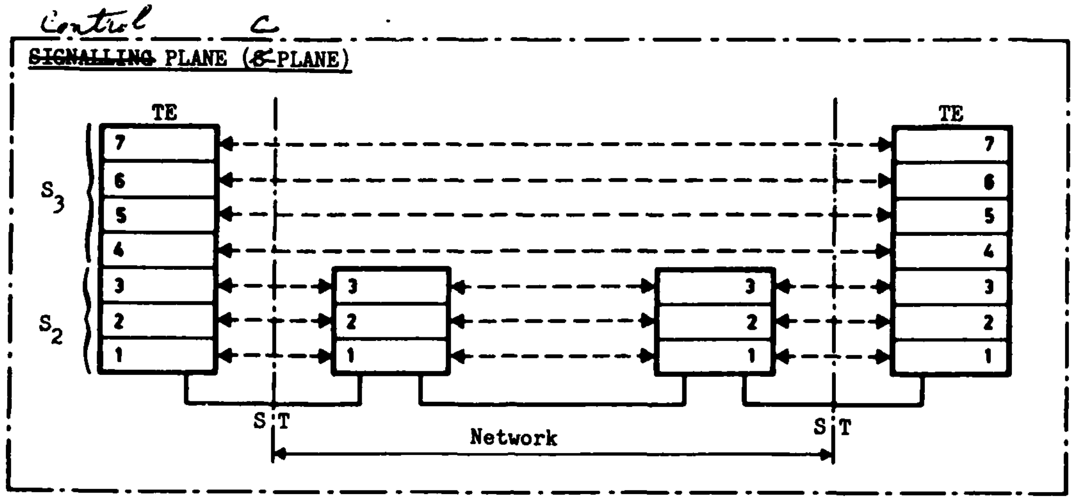

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Figure [illegible] - Application for user-to-user signalling

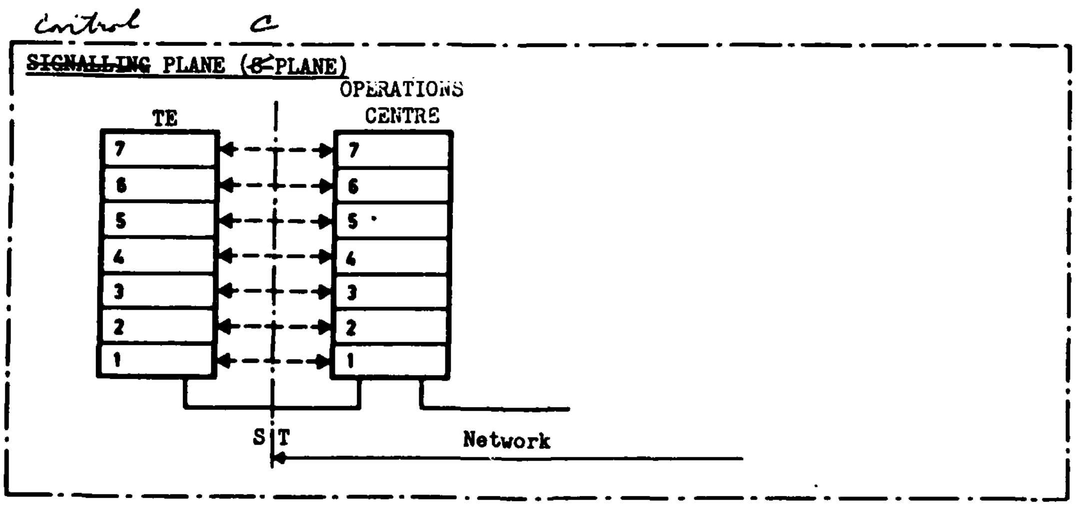

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Figure [illegible] - Application of user-to-operations centre via a local exchange

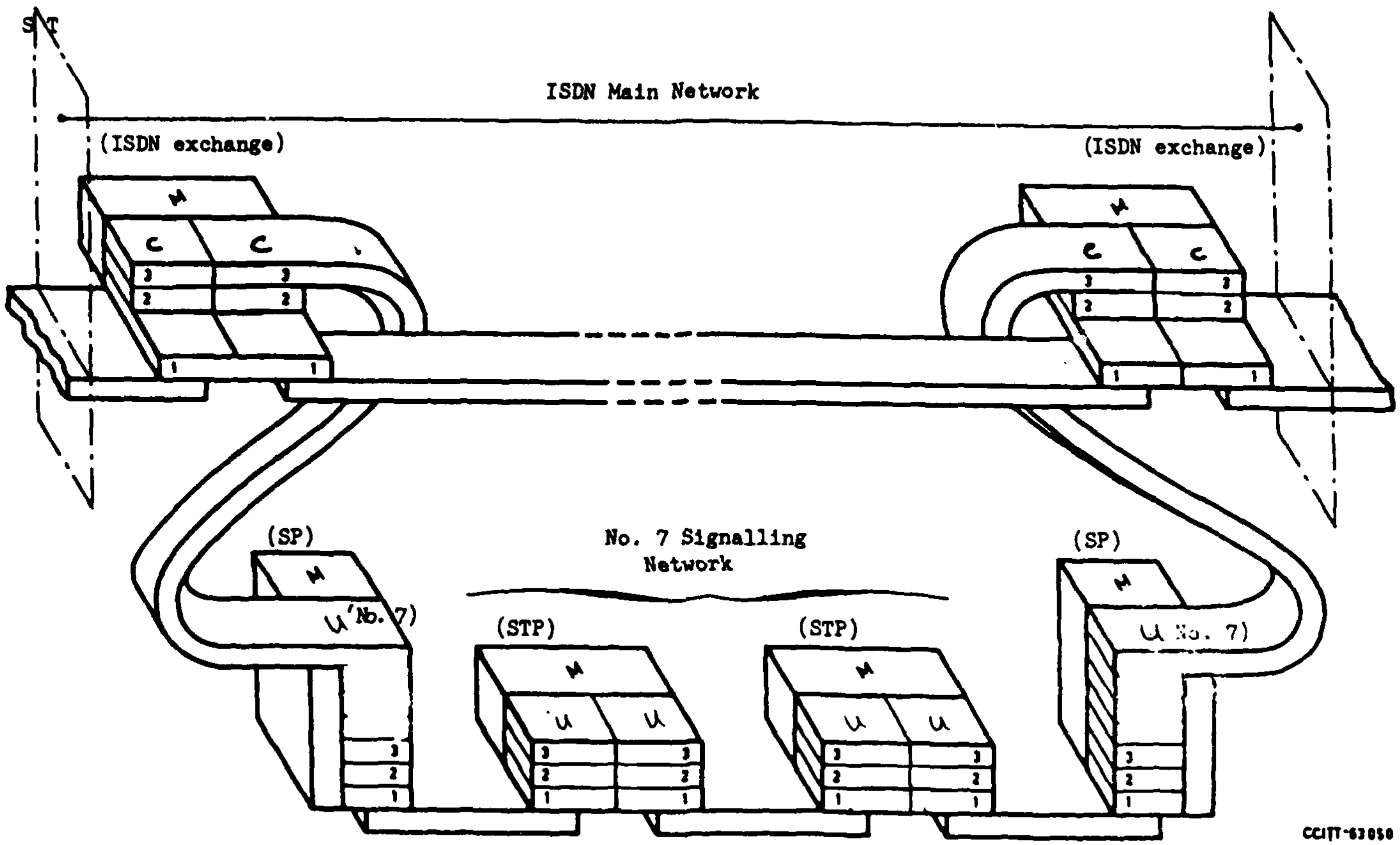

Figure 12 - Relationship between ISDN and No. 7
Signalling Network (three-layer approach used)

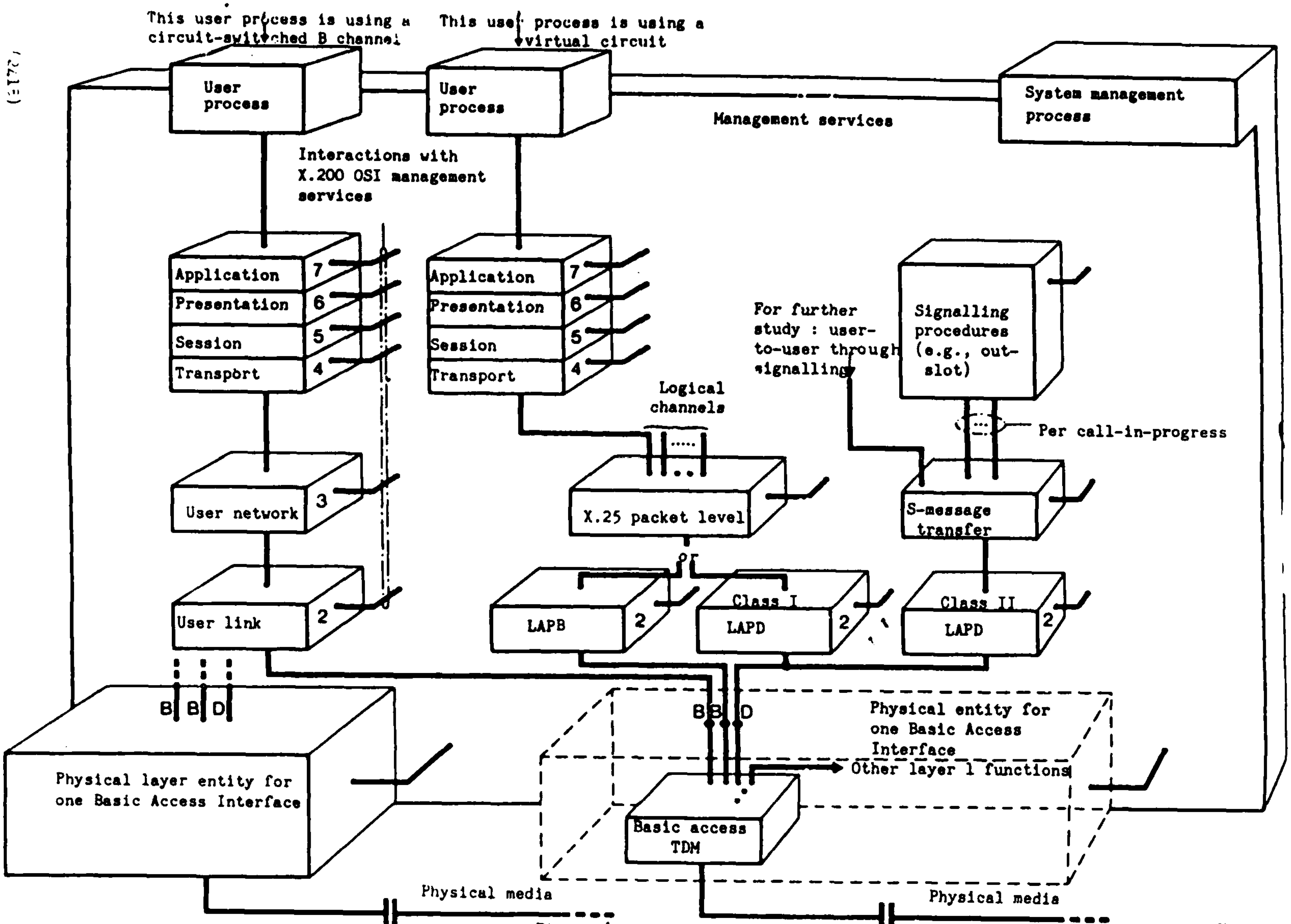

Figure 13 - Example of a TE

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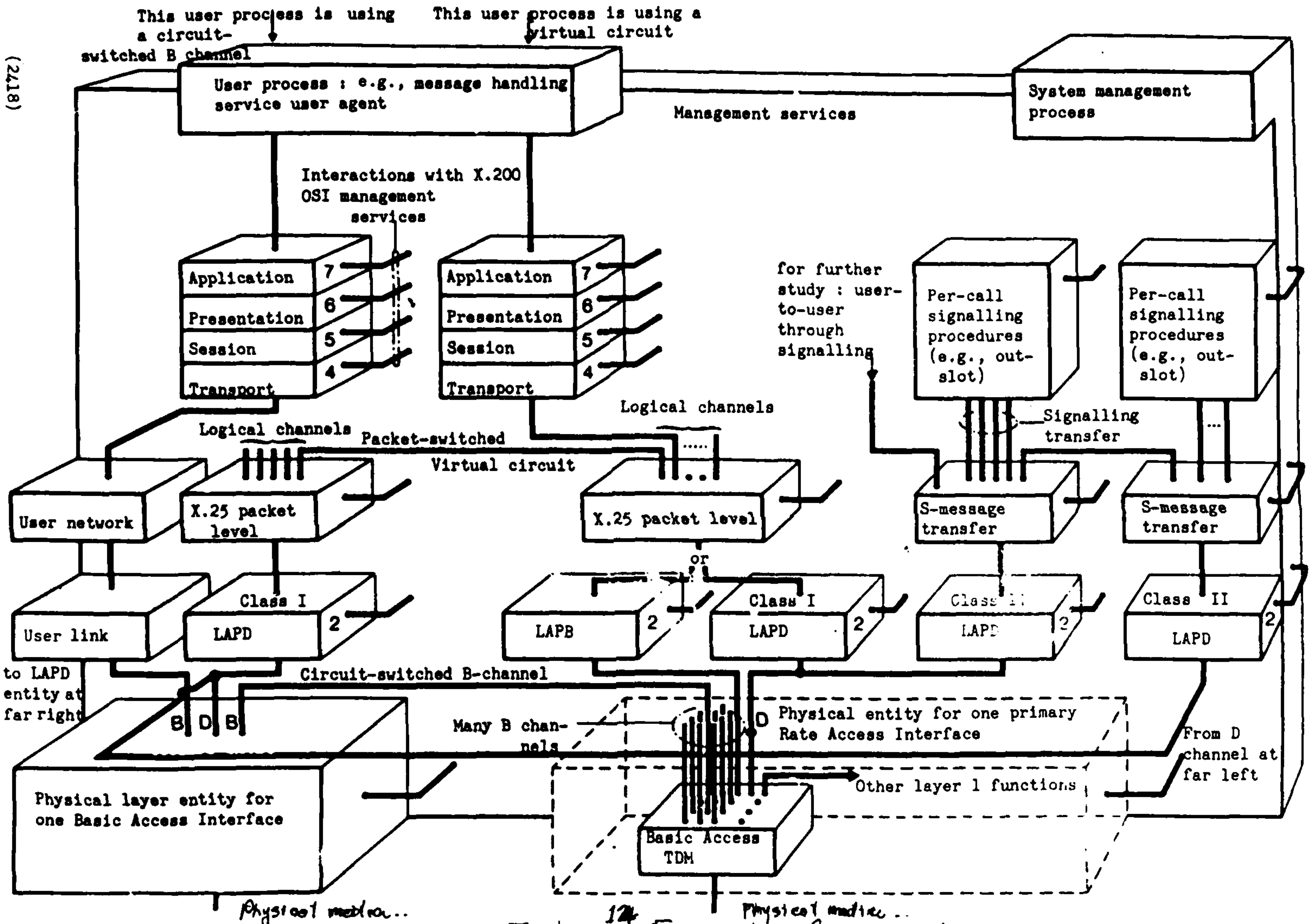

Figure 12 Example of an Exchange.

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STUDY GROUP XVIII

Geneva, 21.11 - 2.12.1983

Question : 1/XVIII, paragraph B

Temporary Document No. 38-E

SOURCE : AD HOC GROUP IN WORKING TEAM 3

TITLE : COMMENTS ON DRAFT REC. I.3XX (PROPOSED I.325) AS GIVEN IN TD 30

DRAFT OF I.3XX - ISDN CONNECTION TYPES

The results of the Drafting Group set up in Plenary to review I.3XX is contained in TD 30.

Subsequent to the issue of TD 30 a major contribution was received from a delegation who had been unable to attend the meeting of the Drafting Grou[p]

Meanwhile, the chairman of the Drafting Group (Mr. Valdar - BT) had returned home, as had several other members of the Drafting Group.

In an attempt to assess the new contribution, and to ease discussions in Plenary, it was decided to establish an Ad Hoc Group to incorporate these comments in draft Rec. I.3XX for consideration in Plenary. The results of this Ad Hoc Group are attached.

It is stressed that this temporary document does not reflect the views of the original Drafting Group, though several members of that group participated in the ad hoc Group.

Draft Rec. I.3xx

ISDN CONNECTION TYPES

The CCITT,

considering

- **that the ISDN concept is described in Recommendation I.120;**

- **that services provided by the ISDN are described in draft Recommendation I.200;**

- **that the ISDN functional architectural model is described in draft Recommendation I.310. That Recommendation describes and defines functional elements in the ISDN. It also provides a functional architectural model which forms the basis of the definition of reference configurations in this Recommendation;**

- **that the ISDN protocol reference model is described in draft Recommendation I.311;**

unanimously declares the view

that the ISDN can be described by a limited set of ISDN Connection types to support ISDN services. This Recommendation defines and identifies these Connection types and their application. They should form the basis for other Recommendations on such matters as Network Performance, etc.

Note - As the ISDN concept evolves other Connection types may be identified.

1. Basic concept of ISDN ~~Network~~ Connection types in an ISDN

1.1 Purpose of ISDN connection types

An ISDN provides a set of network capabilities which enable bearer and telecommunication services to be offered to a user (refer to draft Recommendation I.200). The ISDN lower layer capabilities (refer to draft Recommendation I.310) may be described by a limited set of Connection types which together with additional (lower and/or higher layer) network functions, where appropriate, will support the range of telecommunications and bearer services. The relationship between network connections and services is shown in Figure 1.

The purpose of identifying a set of ISDN Connection types is to assist in the specification of such parameters as network-to-network interfaces and allocation of network performance. The relationship between the service requested and the Connection type provided is covered in section . (It should be noted that subscribers will not be able to selected a particular Connection type.)

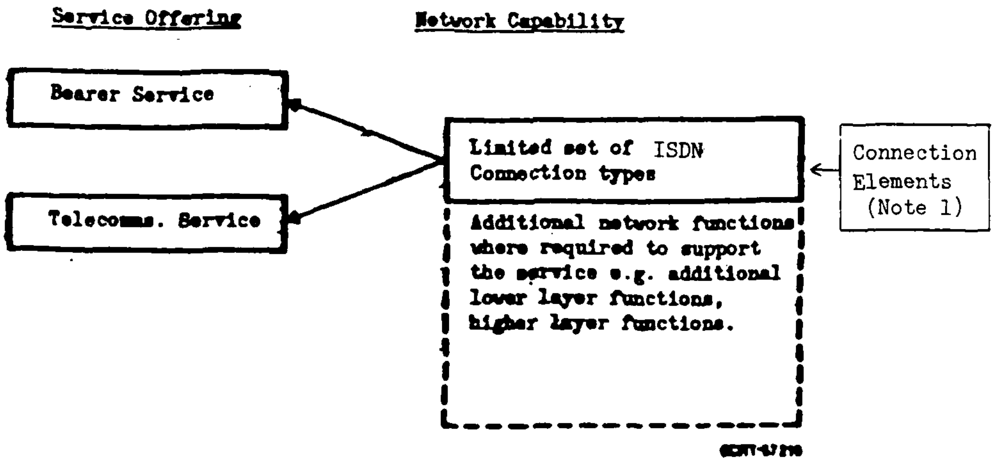

FIGURE 1

Relationship between an ISDN service offering and its network capability

See section for an explanation of Connection Elements.

It should be noted that the terms ISDN Connection type and ISDN Connection have a specific meaning in the context of this Recommendation.

An ISDN Connection type is a description of a form of connection. A particular example of this type is an individual network connection, "so an ISDN Connection is an instance of an ISDN Connection type".

1.2 Functions associated with ISDN connection types

An ISDN Connection is an association of functions to support Bearer and Telecommunication Services as shown in Figure 2. Three sets of functions are required :

i) Connection means - including transmission, switching and routing functions;

ii) Control functions and protocols - including signalling, flow/congestion control;

iii) Operational functions - including network management and maintenance.

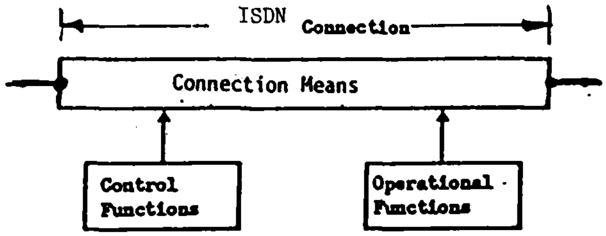

FIGURE 2

Functional description

1.3 Applications of ISDN connection types

ISDN Connection types can apply to three situations which have so far been identified (others may exist) :

- between two user-network interfaces, i.e. between S/T reference points (Figure 3a);

- between a user-network interface and a network-network interface to be defined in Recommendation I.500 (Figure 3b) (for further study);

- between a user-network interface and a network resource (Figure 3c).

Note - Network Resource

Within the context of this Recommendation the term network resource is intended to mean any entity within the network which is accessible by an ISDN connection for the purpose of providing a service at the S/T interface (Figure 3c), or for fulfilling network functions. Use of a network resource originates from a user service request or for internal administration purposes. Some examples are :

1) a network node incorporating ALLF and/or HLF;

2) a network provided data base;

3) an operations or management centre;

4) a database or signal transfer point which forms the end-users of a connection set up by the network to fulfil network functions (billing, signalling, control, etc.).

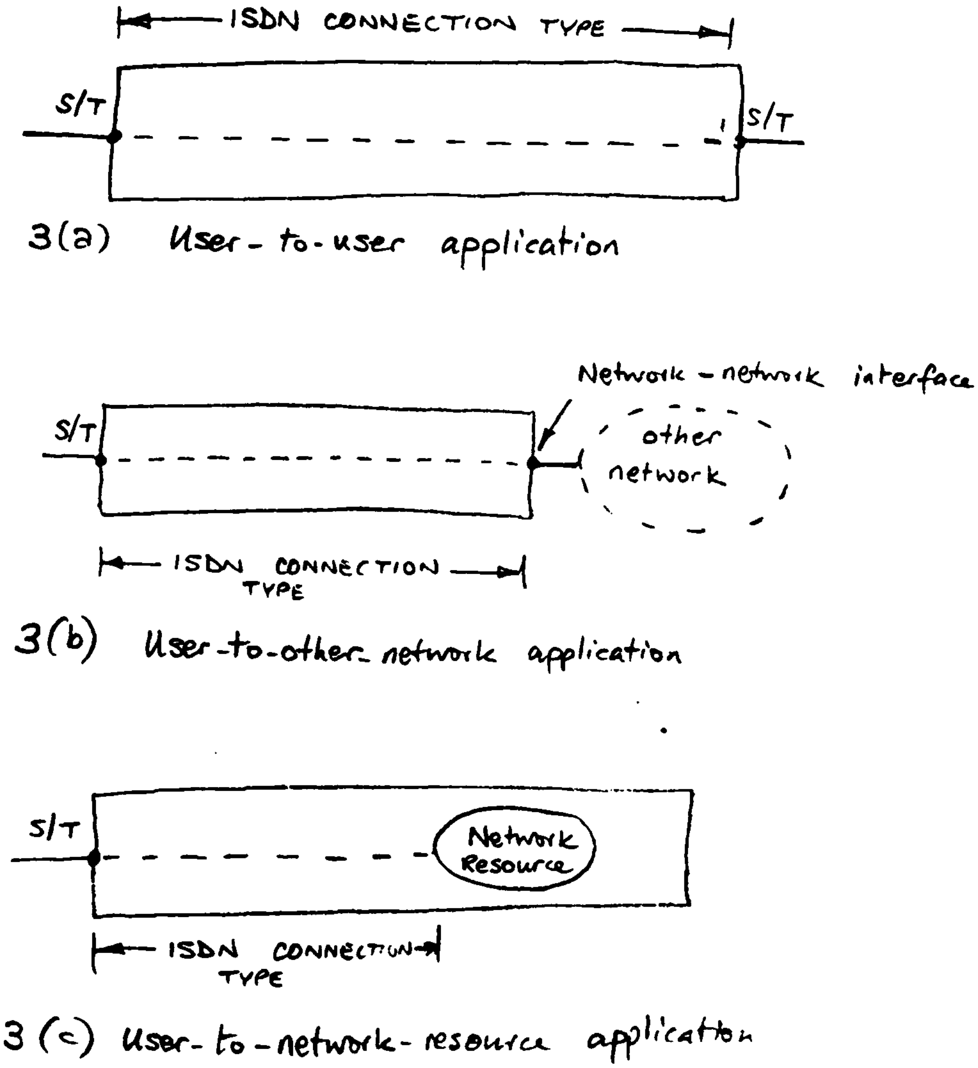

FIGURE 3

Applications of ISDN Connection types

1.4 Attributes of an ISDN connection type

ISDN connection types are characterised by the attributes shown in figure 6.

The limited set of ISDN connection types is given in Table 1.

The attributes which define ISDN connection types ~~elements (particularily those for the local connection element)~~ have a similarity to those used to define Bearer Services in draft Recommendation I.2xx ~~I.200~~. However the two sets of attributes differ in several important aspects.

(i) ISDN Connections represent the technical capabilities of the Network and are a means to standardize interconnection of ISDNs. Bearer Services (~~and other services defined in I.200~~) are the packages offered to customers and standardisation of their attributes is the means to standardising the service offerings world-wide.

(ii) A second major difference is that operational and commercial attributes are relevant to bearer services, whereas operations and maintenance attributes are relevant to connection types.

1.5 ISDN connection elements

ISDN Connection types may be considered to be composed of Connection Elements, each described by a set of attributes. This concept is illustrated in Figure 4, which could represent an example of 64 kbit/s circuit switched network connection in a national ISDN in which Connection Elements 1 and 3 represent the access portion and Connection Element 2 represents the National transit portion of the connection.

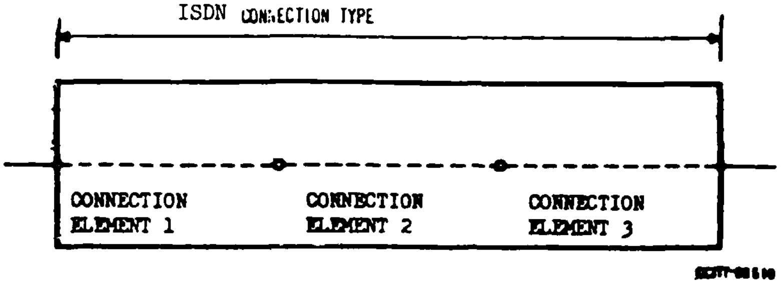

FIGURE 4

Example of Connection Elements forming an ISDN Connection type

1.6 ISDN connection types involving several networks

Some ISDN Connection types may be formed from a number of Connection Elements which are contained in separate networks. These separate networks may or may not be ISDNs, but in either case they support the attributes of the ISDN Connection type. Inter-network interfaces exist between each network. This is shown in Figure 5.

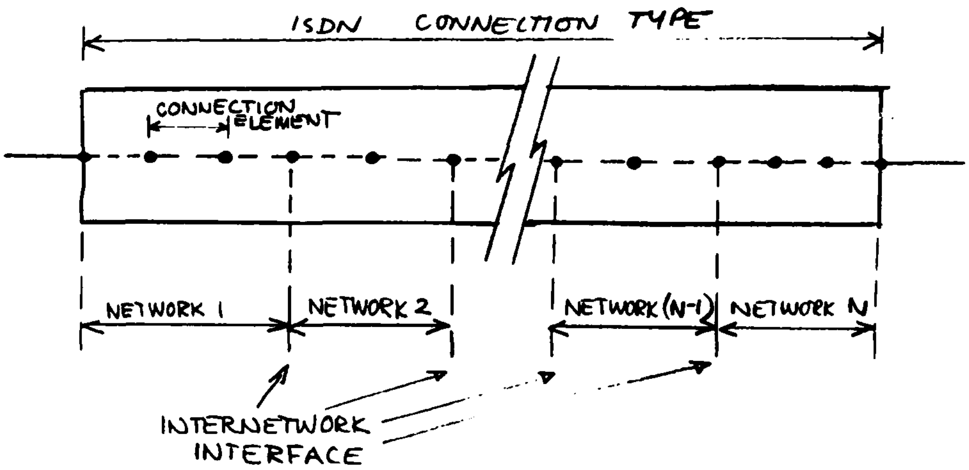

FIGURE 5

Example of Connection Elements forming an ISDN Connection type involving several networks

ATTRIBUTES for connection types and connection elements

Attributes	Applicable to Local (L) / Transit (T)	Possible value of attribute
1. Mode of Connection	L + T	CCT. SWITCHED | PKT SWITCHED
2. Establishment of* ‡ Connection (Level 1)	L + T	DEMAND | RESERVED | PERMANENT
3. ~~Throughput, bit rate~~ channel capability	L + T	BIT RATE | THROUGHPUT + X
4. Transparency*	L + T	TRANSPARENT | NON-TRANSPARENT | OTHERS
5. Information transfer protocol	L + T	UNDER STUDY | X.25 Level 3 | Others Eg X75 B?
6. Symmetry	L + T	SIMPLEX | HALF DUPLEX | DUPLEX - SYMMETRIC | DUPLEX NON-SYMMETRIC
7. Access Channels	L	D(16) | D(64) | B | H(384) | Under Study
8. Access Protocols	L	Basic Access Q930 etc | Extended Access Q930 etc | FS
9. ~~Network~~ Performance	L + T	Further Study
10. Operations and Maintenance	L + T	Further study
11. Inter-exchange Connection Protocol	T	SS # 7 ISUP

For further study.

FIGURE 6

Possible attributes for Connection types and connection elements

* Provisional definitions of the values of these attributes are given in Appendix 1.

1.7 Association rules for attributes of ISDN connection elements

Connection elements are also defined by a set of attributes (see figure 6). Some of these attributes are of a general or dominating nature leading to a limited set of ISDN connection types as described in section 1.4. This limited set of connection types will have the capability to support the Bearer Services defined in draft Rec. I.200 but they are not intended to limit the ways by which a network provider implements those services. This is because within a set of connection elements comprising a connection type, other attributes can vary to produce various connection types all of which may be suitable to support a particular Bearer Service. It should be noted that the structure of fig. 6 does not imply that all possible combinations of attributes will lead to standardized or even useful examples of connection elements.

The above considerations lead to a series of association rules by which the attributes of individual connection elements determine the attributes for a connection type. For example,

i) if any one or more connection elements involves a packet attribute, then the attributes of the connection type is packet

ii) if any one or more connection elements involves a non-transparent attribute, then the attribute of the connection type is non-transparent

iii) if one connection element has the lowest channel capability, then the channel capability attribute of the connection type has the channel capability of that connection element.

An example of the way the attributes of connection elements determine the attributes of the connection type is shown in fig. 7, which shows a set of connection elements making up a connection type for a packet call over a B channel.

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Example NCT: Pkt call over B channel to Pkt Network Gateway in other country

Conn-ection Element \ Attribute	1 Mode	2 Estab of Conn	3 Rate	4 Transp	5 Info transfer Protocol	6 Symmetry	7 Access Channel	8 Access Protocols	9 N.P.	10 O + M	11 Inter-Exchange Protocols	Connection elements involved	Connection Configuration - Topology	- Uniformity	- Dynamics	Interworking involved
Local CE	Cct Sw	Dem	64	Trans	X.25	DS	B	BA								
National transit CE	Cct Sw	Dem	64	Trans	X25	DS			Further Study	Further Study						
Intern. transit CE	Cct Sw	Dem	64	Trans	X25	DS					SS#7					
National transit CE	Cct Sw	Dem	64	Trans	X25	DS										
Local CE (Pkt Network Gateway)	Cct Sw	Res	64	Trans	X25	DS										
Association Rule																
Network Connection type attribute	Cct Sw	Dem	64	Trans	X.25	DS	-					3	Point to Point	Non Uniform	Concurrent	None

* CEs involved only in International Calls

FIGURE 7

3. Relationship between ISDN Connection types and Connection Elements

Section 1 introduced the concept of subdividing an ISDN Connection type into Connection Elements which are characterized by a set of attributes.

In general Connection Elements may be combined in space or in time, or both, to form Connections.

There are three general categories of Connection Elements (CEs) :

i) Local Connection Elements. This is the part of the ISDN Connection type from the S or T reference point to the output side of the Local Connection related function. Examples are given in Figure 10.

ii) Transit Connection Elements. This is the part of the ISDN Connection which in the case of :

a) a National Call is between the two Local Connection Elements;

b) an International Call is between the end of the Local Connection Element and the output of the International Switching Centre;

c) an international call between the end of the two National Connection Elements.

3.1 This section presents a framework and terminology for describing the configuration of ISDN Connection types which consists of multiple Connection Elements. Such configurations can be described by four attributes: topology, uniformity, dynamics and Connection Elements involved (figure 8).

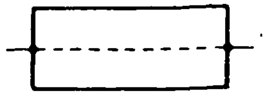
Topology refers to the way that Connection Elements are arranged to form the ISDN Connection. Example topologies are: point-to-point, tandem, parallel, hub and combinations of these topologies (figure 8 a)).

Uniformity refers to the attributes of the individual Connection Elements (figure 8 b)). When all of the Connection Elements in a configuration have the same attributes, the configuration is described as uniform. When the Connection Elements are different, the configuration is described as non-uniform.

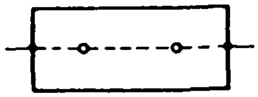
Dynamics refer to the way the Connection Elements are established in time (figure 8 c)). When all of the Connection Elements are established simultaneously and released simultaneously, the configuration is described as concurrent. When the Connection Elements are established and released sequentially (i.e. only one Connection Element chain exists at any given time) the configuration is described as sequential. When Connection Elements can be established or released while other Connection Elements exist, the configuration is described as add/remove.

a) Topology

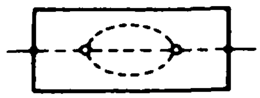
i) Point-to-point; simple



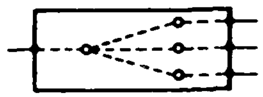
ii) Point-to-point; tandem



iii) Point-to-point; parallel



iv) Point-to-multipoint; hub



v) Others (for further study)

b) Uniformity

i) Uniform (All Connection Elements identical)

ii) Non-uniform (Some Connection Elements different)

c) Dynamics

i) Concurrent (All Connection Elements established and released simultaneously)

ii) Sequential (Only one Connection Element established at a given time)

iii) Add/remove (Connection Elements may be added and/or removed during a call)

Figure 8 - Description of Connection Configuration

The dynamics of an ISDN Connection type do not have to be identical to the dynamics of the service(s) it supports. For example, a service which allows a customer to alternately send voice or data (i.e. a sequential service) could be supported by a concurrent connection for which only one of the Connection Elements is made available to the customer at any given time. Alternatively, a single Network Connection type could be defined which could have one of its attributes modified during a call (e.g. switching in and out of A/Mu law converters).

4. Relationship between services and ISDN Connection types

This relationship can be described by taking account the communication capabilities associated with Bearer and Telecommunications services. A "Communication Capability" is defined as a set of rules characterizing the use made within the network of the different ISDN Connection types. The Communication capability is based on three groups of ISDN Connection types, (CT) :

i) Preferred ISDN Connection type group

A Communication capability is based on the use of any ISDN CT in the group. However, one ISDN CT is preferred, for example :

For the telephony service, the Communication capability is based on either a Non-transparent 64 kbit/s connection (preferred), or a transparent 64 kbit/s connection. (A particular case is a 1-1 association of Bearer service to Connection type.)

ii) Alternative group

During a service communication, the Communication capability is based on the alternative use of different ISDN CTs, for example :

Universal service - change of ISDN CT during a call (the corresponding attributes are not the dominant attributes).

iii) Simultaneous group

The Communication capability is based on the use of several ISDN TCs simultaneously, for example, multi-media services.

5. Reference configurations

Based on the concepts which define the functionality of ISDN connections in draft Rec I.310, figure 9 below shows the general concept of ISDN Connection type.

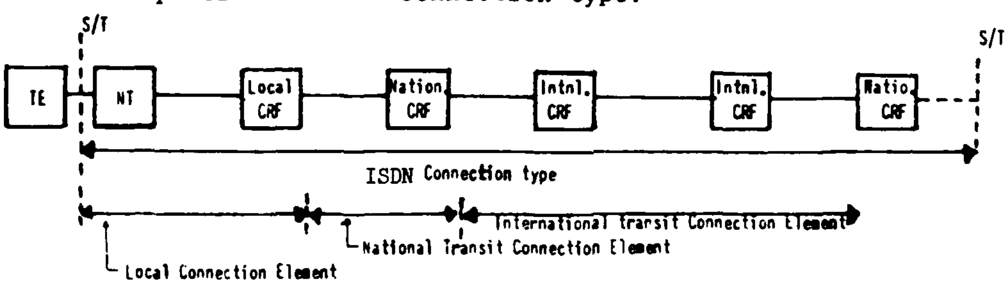
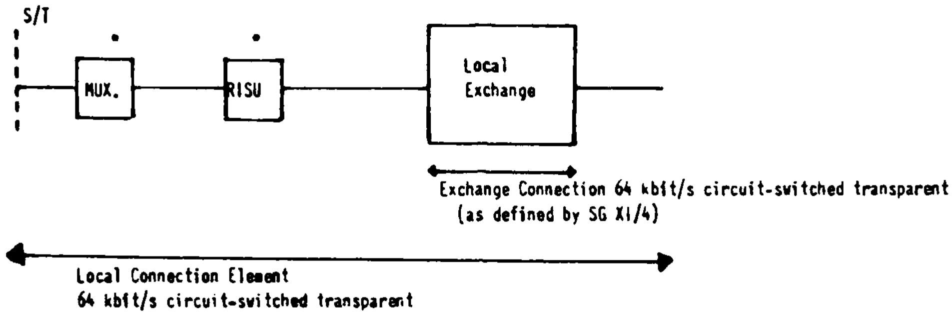


Fig 9: General Concept of ISDN Connection Type and Connection Elements

As defined in draft Rec I.310 the Connection Related Function (CRF) includes functions such as exchange terminations switching, control network management, operations and maintenance. So in the case of the local CRF it is the point where the level 1 functions are switched and the level 3 protocols terminate. Similarily the National CRF represents the functional units involved in switching in the national network (which could involve several switching centres) and the International CRF represents the functional units involved in switching in the international network. The links between these CRFs represent transmission systems.

Examples of local Connection Elements for (a) 64 kbit/s circuit switched transparent and (b) packet switched virtual circuit in D channel are shown in fig 10.



* Note: The inclusion of a remote multiplexer and/or a remote system independent switching unit are possible options for network providers.

Fig 10(a): Reference Configuration for 64 kbit/s circuit-switched transparent local connection Element

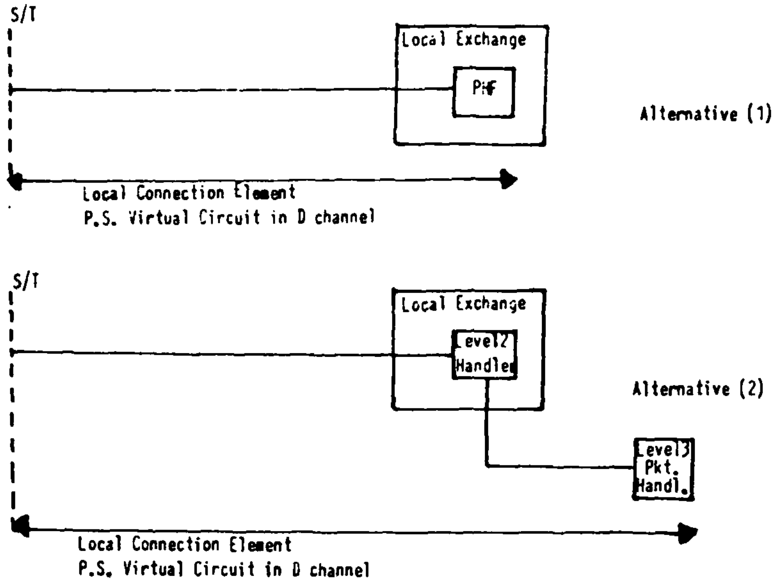


Fig10 (b) Reference Configuration for Packet Switched Virtual Circuit in D Channel Local Connection Element

Appendix 1

(to draft Recommendation I.3xx)

Definitions of different values of

(A) Attribute : "Establishment of Connection"

Three categories have been proposed :

Demand

They are set up on demand at any time.

They are set up and cleared down in response to subscriber control procedures.

The duration of the connection is unspecified.

Reserved

They are set up following subscriber application, either by operator action, or in response to subscriber signalling control procedures.

They are cleared without further action after subscription .

They are set up for a fixed period of time, or for an agreed period during a day, week, or other interval.

Permanent

They are set up, following subscriber application either by operator action, or in response to subscriber control procedures.

Only the starting time is given at the time of application. Clear down requires another inter-action.

They are set up for an indefinite period.

(B) Attribute : "Transparency"

For further study.

NO	DESCRIPTION	1 MODE OF CONNECTION	2 ESTABLISHMENT OF CONNECTION	3 CHANNEL CAPABILITY (KBIT/S)	4 TRANSPARENCY	5 INFO TRANSFER PROTOCOL	6 SYMETRY	7 ACCESS CHANNEL	8 ACCESS PROTOCOL	9 PERFORMANCE	10 O. & M.	11 INTER-EXCHANGE PROTOCOL
1	64 kbit/s	CIRCUIT	SWITCHED	64	TRANSPARENT	—	DUPLEX NOTE 2	B	I.451	* NOTE 4	*	CCSS NO.7
2		CIRCUIT	NON-SWITCHED	64	TRANSPARENT	—	DUPLEX NOTE 2	B	—	* NOTE 4	*	CCSS NO.7
3	VOICEBAND NOTE 1	CIRCUIT	SWITCHED	NOTE 1	NON-TRANSPARENT	—	DUPLEX NOTE 2	B	I.451	*	*	CSSS NO.7
4		CIRCUIT	NON SWITCHED	NOTE 1	NON TRANSPARENT	—	DUPLEX NOTE 2	B	—	*	*	CSSS NO.7
5	BROADBAND	CIRCUIT	NON SWITCHED	384	TRANSPARENT	—	DUPLEX NOTE 2	H0	—	*	*	*
6		CIRCUIT	NON SWITCHED	384	NON TRANSPARENT	—	DUPLEX NOTE 2	H0	—	*	*	*
7		CIRCUIT	NON SWITCHED	1536	TRANSPARENT	—	DUPLEX NOTE 2	24 B / 1536 kbit/s	—	*	*	*
8		CIRCUIT	NON SWITCHED	1920	TRANSPARENT	—	DUPLEX NOTE 2	30 B / 1920 kbit/s	—	*	*	*
9	PACKET	PACKET	SWITCHED (SVC) NOTE 5	NOTE 3	TRANSPARENT	X.25 LEVEL 3	DUPLEX SYMETRIC	B or D	X.25/I.451	*	*	X.75
10		PACKET	NON SWITCHED (PVC)	NOTE 3	TRANSPARENT	X.25 LEVEL 3	DUPLEX SYMETRIC	B or D	—	*	*	X.75

TABLE 1 : SET OF CONNECTION TYPES

NOTES
1. CHANNEL CAPABILITY TO SUPPORT VIRTUAL ANALOGUE SERVICES TO INCLUDE 3.1 kHz BANDWIDTH
2. ATTRIBUTE MAY BE SYMETRIC OR ASYMETRIC
3. VIRTUAL CIRCUIT THROUGHPUT TO BE DEFINED AS A SERVICE ATTRIBUTE
4. TRANSMISSION PERFORMANCE SHOULD BE IN ACCORDANCE WITH REC G.821
5. INCLUDES FAST SELECT OPTION
6. CONNECTIONS MAY BE COMPRISED OF NON-HOMOGENEOUS COMBINATIONS OF CONNECTION ELEMENTS
7. * INDICATES VALUE OF ATTRIBUTE IS FOR FURTHER STUDY.

I.431

1. General

1.1 Introduction (to be drafted)

1.2 Scope and field of application

This Recommendation defines the layer 1 characteristics of the user to network interface to be applied at the S or T reference points for the basic channel structure defined in I.410.

In the following, NT will be used to indicate arrangements of NT1 and NT2 and TE will be used to indicate TE1 or TA or NT2, unless otherwise stated.

2. Service Characteristics

2.1 Services required from the Physical Medium

2.2 Services Provided to Layer 2

Layer 1 provides the following services to Layer 2:

2.2.1 Transmission capability by means of appropriately encoded bitstreams, for both B and D channels and also any related timing and synchronization functions.

2.2.2 The signalling capability and the necessary procedures to enable customers terminals and/or network terminating equipment to be deactivated (i.e., placed in a low power-consumption mode) when required and reactivated when required. The activation and deactivation procedures are defined in sections 6.2 and 6.3.

2.2.3 The signalling capability and the necessary procedures to allow terminals to gain access to the common resource of the D channel in an orderly fashion while meeting the performance requirements of the D channel signalling system. These D channel access control procedures are defined in section 6.1.

2.2.4 The signalling capability and procedures and necessary functions at layer 1 to enable the general maintenace principles defined in Recommendations Q.950 to be implemented as required.

2.2.5 An indication to the higher layers of the status of layer 1 (e.g., activate indication or deactivate indication).

2.3 Primitives between Layer 1 and Layer 2

To facilitate the correct interaction between Layer 1 and higher layers, the primitives to be passed across the layer 1/2 boundary are defined and summarized in Table 1.I.431. The parameter values associated with these primitives are summarized in Table 2/I.431. For a description of the syntax and use of the primitives, refer to Recommendation X.211 and relevant detailed descriptions in section 6 of this Recommendation. Table 3/I.431 defines the primitives passed between Layer 1 and Layer 2 (or the Management entity).

TABLE 1/I.431

Primitives between layers 1 and 2

PRIMITIVE GENERIC NAME	REQUEST	INDICATION	RESPONSE	CONFIRM
Data	X	X		
Activate	X	X		
Deactivate	X	X		

TABLE 2/I.431

Primitive Parameters

PRIMITIVE GENERIC NAME	PRIORITY INDICATOR	MESSAGE UNIT
Data	X	X

3. Modes of operation

Both point-to-point and point-to-multipoint modes of operation, described below, are intended to be accommodated by the layer 1 characteristics of the interfaces. In this Recommendation, the modes of operation apply only to the layer 1 procedural characteristics of the interface and do not imply any constraints on modes of operation at higher layers.

3.1 Point-to-point

Point-to-point operation at layer 1 implies that only one source (transmitter) and one sink (receiver) are active at the interface at any one time. (Such operation is independent of the number of interfaces which may be provided on a particular wiring configuration - see section 4.)

3.2 Point-to-multipoint

Point-to-multipoint operation at layer 1 allows more than one terminal (source and sink pair) to be simultaneously active at an S or T reference point. (The multipoint mode of operation may be accommodated, as discussed in section 4, with point-to-point or point-to-multipoint wiring configurations.)

4. Types of wiring configuration

In order to determine the electrical characteristics of the User/Network Interface, it is necessary to make certain assumptions about the various wiring configurations which may exist within the users premises. These assumptions are identified in two major configuration descriptions below, together with additional material contained in Annex 1 to this Recommendation. Figure 1 shows a general Reference Configuration.

A precise location of the User/Network Interface(s) is also necessary for electrical definition. Figure 1/I.431 is a general Reference Configuration.

4.1 Point-to-point

Point-to-point wiring configuration implies that only one source (transmitter) and one sink (receiver) are interconnected on an interchange circuit.

4.2 Point-to-multipoint

Point-to-multipoint wiring configuration allows more than one source to be connected to the same sink or more than one sink to be connected to the same source with an interchange circuit. Such distribution systems are characterized by the fact that they contain no active logic elements performing functions (other than possibly amplification or regeneration of the signal).

4.3 Wiring polarity integrity

For point-to-point wiring configuration the two wires of the interchange circuit pair may be reversed. However, for point-to-multipoint wiring configuration, the wiring polarity integrity of the interchange circuit (TE to NT) must be maintained between TEs.

4.4 Location of the interface

The wiring in the user premises is considered to be one continuous cable run with sockets for the TE and NT equipment attached directly to the cable or via stubs < 1 metre in length.

The sockets constitute two potential interface location points. One interface would be adjacent to each TE and the other interface would be adjacent to the NT. It is desirable for these interface points to be electrically equivalent.

4.5 NT and TE associated wiring

The wiring from the NT or TE equipment to its appropriate socket can affect the interface electrical characteristics. Thus a connecting lead of not more than 10 metres and a suitable plug are considered to form part of the NT and TE equipment.

5. Functional characteristics

5.1 Interface functions

5.1.1 B-channel

This function provides for the bi-directional transmission of the two independent B-channels each having a bit rate of 64 kbit/s as defined in Recommendation I.432.

5.1.2 Bit timing

This function provides bit (Signal Element) timing at 192 kbit/s to enable the terminal or NT2 to recover information from the aggregate bit stream.

5.1.3 Octet timing

This function provides 8 kHz octet timing towards the terminal or NT2, primarily, for the purpose of enabling correct operation of PCM voice encoders but which may be used for other purposes as required.

5.1.4 Frame alignment

This function provides information to enable the terminal or NT2 to recover the time division multiplexed channels.

5.1.5 D-channel

This function provides for the bi-directional transmission of one D-channel, as defined in Recommendation I.412 at a bit rate of 16 kbit/s.

5.1.6 D-channel access control

This function is specified to enable terminals to gain access to the common resource of the D-channel in an orderly, controlled fashion. The functions necessary for these procedures include an echoed D-channel at a bit rate of 16 kbit/s in the direction NT to TE (or NT2). For the definition of the procedures relating to D-channel access control see section 6.1.

5.1.7 Power feed

This function provides for the capability to transfer power across the interface. The direction of power transfer depends on the application. In a typical application it may be desirable to provide for power transfer from the network side towards the terminals in order to, for example, maintain a basic telephony service in the event of failure of the locally provided power. (In some applications undirectional power feeding or no power feeding at all access the interface may apply.) The detailed specification of power feeding capability is contained in section 8.

5.1.8 End point deactivation

This function is specified in order to permit terminals and NT equipment to be placed in a low power consumption mode when no calls are in progress. The procedures and precise conditions under which such deactivation takes place are specified in section 6.3.

5.1.9 End point activation

This function allows the terminal or NT2 to be restored to its normal operating power mode. The procedures and precise conditions under which such activation takes place are defined in section 6.2.

5.2 Interchange circuits

Two interchange circuits, one for each direction of transmission, shall be used to transfer digital signals across the interface. All of the functions described in section 5.1, except for power feeding, shall be carried by means of a digitally multiplexed signal structured as defined in section 5.4.

5.3 Configuration indication

The TE shall determine the following conditions :

a) disconnected;

b) connected to a point-to-point wiring configuration;

c) connected to a point-to-multipoint wiring configuration.

The TE distinguishes (see Note) conditions b) or c) from a) by sensing the presence of a resistance terminating the leads designated 1 and 2 in Figure 4. The terminal distinguishes (see Note) condition b) from condition c) by sensing the value of the resistance. The resistance is determined by a resistor located in the jack terminating the interconnecting cable and connected between the appropriate pins. The different resistor values for point-to-point and multipoint wiring configuration is for further study.

Note : Alternative methods for distinguishing these conditions should be studied.

A.100

CCITT

Temporary Document No. 41-E

STUDY GROUP XVIII

Geneva, 21.11 - 2.12.1983

Question : 1C/XVIII

SOURCE : DRAFTING GROUP

TITLE : AMENDMENT TEXT OF § 5.3 of I.431

5.3 Detection disconnected state

The detection of the connected/disconnected state is used for initiating the TEI assignment procedures and the activation/deactivation procedures.

A TE shall enter the connected state and initiate renegotiation of its TEI when it is powered (or repowered) up and/or after it detects the reappearance of input framing signals (assuming its prior detection of the cessation of such signal). As an alternative to initiating such renegotiation in response to the detection of the reappearance of framing signals, a TE, that is connected to an interface on which voltage appears in the phantom mode (power source 1 in section 9.1), may enter the connected state and initiate such renegotiation upon the detection of the reappearance of the phantom mode voltage. (This latter operation is preferred where voltage is available on the phantom).

Note : Alternative methods for detecting this state should be studied.

5.4 Frame structure

In both directions of transmission, data shall be grouped into frames of 48 bits each. The frame structure shall be identical for all configurations (point-to-point and point-to-multipoint). All bits reserved for future standardization shall be set to binary "0".

5.4.1 Bit rate

The norminal transmitted bit rate at the interface shall be 192 kbit/s in both directions of transmission. Each 48 bit frame, therefore, has a nominal duration of 250 microseconds. The precise bit rate is determined by the network clock frequency.

5.4.2 Binary organization of the frame

The frame structures are different for each direction of transmission. Both structures are illustrated diagrammatically in Figure 2/I.431.

5.4.2.1 Terminal to network

Each frame consists of the following groups of bits; each individual group is DC-balanced by a trailing balance bit (L-bit) :

bit position	group
1 and 2	framing signal with balance bit
3 - 11	B1-channel with balance bit
12 and 13	D-channel bit with balance bit
14 and 15	auxiliary framing bit with balance bit
16 - 24	B2-channel with balance bit
25 and 26	D-channel bit with balance bit
36 and 37	D-channel bit with balance bit
38 - 46	B2-channel with balance bit
47 and 48	D-channel bit with balance bit

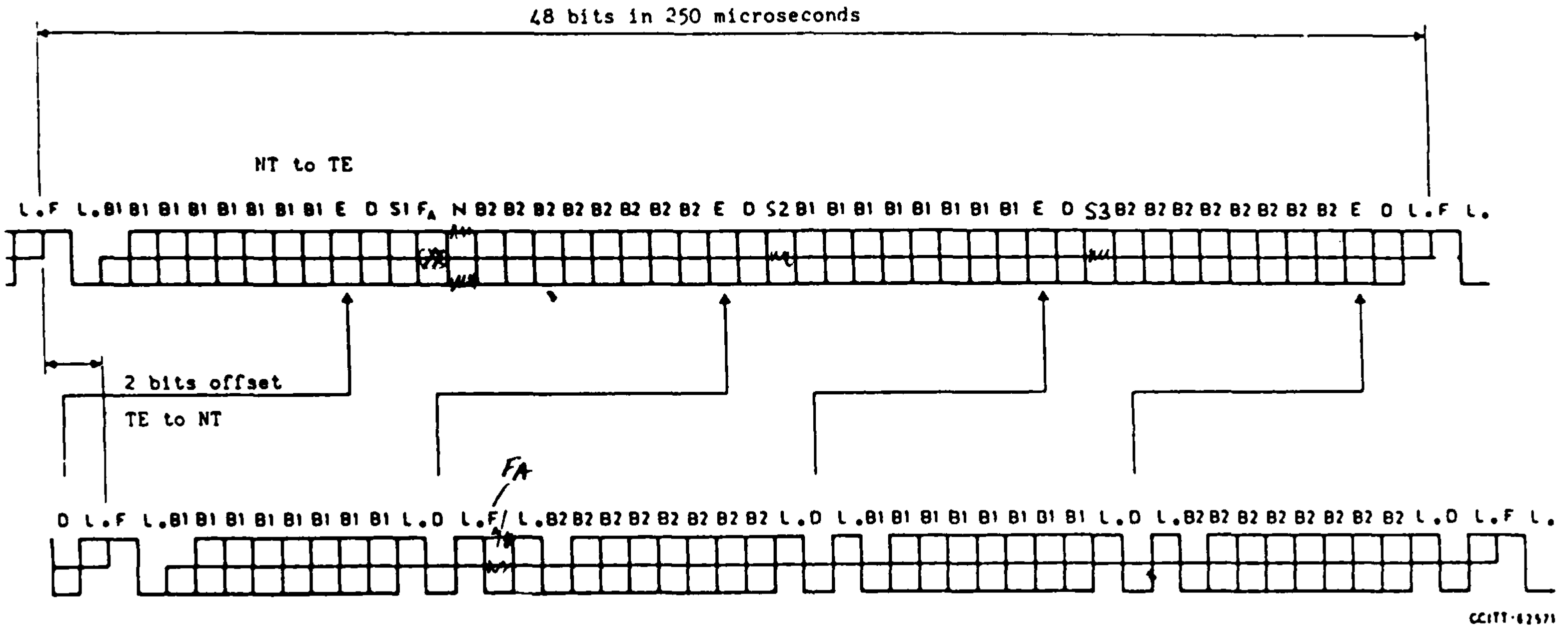
5.4.2.2 Network to terminal

Frames transmitted by the network (NT) contain an echo channel (E-bits) used to re-transmit the D-bits received from the terminals. The D-echo channel is used for D-channel access control. The last bit of the frame (L-bit) is used for balancing each complete frame.

The bits are grouped as follows :

bit position	group
1 and 2	framing signal with balance bit
3 - 10	B1-channel
11	D-echo channel bit
12	D-channel bit
13	Reserved for future standardization

bit position	group
14	auxiliary framing bit
15	N bit (Coped as defined in section 6.3)
16 - 23	B2-channel
24	D-Echo channel bit
25	D-channel bit
26	Reserved for future standardization
27 - 34	B1-channel
35	D-Echo channel bit
36	D-channel bit
37	Reserved for future standardization
38 - 45	B2-channel bit
46	D-Echo channel bit
47	D-channel bit
48	frame balance bit



F = framing bit
L = DC balancing bit
D = D-channel bit
E = D-echo-channel bit
F_A = Auxiliary framing bit = ϕ (unless set to 1 for multiframing indication) see §6.3.3.

N = bit set to a binary Value $\boxed{N = \overline{F_A}}$ (N NOT EQUAL TO F_A) Note!, see §6.3.3 for possible multiframing applications
B1 = bit within B channel 1
B2 = bit within B channel 2
$S_1 S_2 S_3$ = RESERVED FOR FUTURE STANDARDIZATION. Until then, set to ϕ.
Dots mark those parts of the frame that are independently DC-balanced.

Figure 2/I.431 - Frame structure at reference points S and T

6.1 D-channel access control

The following procedure allows for a number of terminals connected in a multipoint configuration to gain access to the D-channel in an orderly fashion. The procedure ensures that, even in cases where two or more terminals attempt to access the D-channel simultaneously one terminal will always be successful in completing transmission of its information.

6.1.1 Interframe (layer 2) time fill

Information on the D-channel is transmitted in layer 2 frames delimited by flags consisting of the binary pattern 01111110. When a TE or NT has no Layer 2 frames to transmit, it shall send binary "ones" on the D-channel.

6.1.2 D-echo channel

NT1 or NT2 on receipt of a D-channel bit from TE or TEs shall reflect this condition in the next available D-echo channel bit position towards the terminal(s).

6.1.3 D-Channel Monitoring

A terminal, while in the active condition, shall monitor the condition on the D-echo-channel for the number of consecutive ONE-bits. If a ZERO-bit is detected the terminal shall restart counting the number of consecutive ONE-bits. The current value of the counter is called C.

(Implementation dependent)

6.1.4 Priority Mechanism

Layer 2 frames are transmitted in such a way that signalling information is given priority (priority class 1) over all other types of information (priority class 2). Furthermore - to ensure that within each priority class all competing terminals are given a fair access to the D-channel - once a terminal has successfully completed the transmission of a frame, it is given a lower level of priority within that class. The terminal is given back its normal level within a priority class when all terminals have had an opportunity to transmit information at the normal level within that priority class.

The priority class of a particular layer 2 frame may be a characteristic of the terminal which is preset at manufacture or at installation or it may be passed down from layer 2 as a parameter of the PH-Data Request primitive.

The priority mechanism is based on the requirement that a terminal may only start layer 2 frame transmission when C (see section 6.1.3) is equal to or exceeds the value X1 for priority class 1 or is equal to or exceeds the value X2 for priority class 2. The value of X1 shall be 8 for the normal level and 9 for the lower level of priority. The value of X2 shall be 10 for the normal level and 11 for the lower level of priority.

In a priority class, the value of the normal level of priority is changed into the value of the lower level of priority when a terminal has successfully transmitted a frame of that priority class. The value of the lower level of priority is changed back to the value of the normal level of priority when the counter (see section 6.1.3) has reached a value C which equals the value of the lower level of priority.

6.1.5 Collision detection

While transmitting information in the D-channel the terminal shall monitor the received D-echo channel and compare the last transmitted bit with the next available D-echo bit. If the transmitted bit is the same as the received echo, the terminal shall continue its transmission. If, however, the received echo is different to the transmitted bit the terminal shall cease transmission immediately and return to the D-channel monitoring state.

6.1.6 Annex A to this Recommendation is an example of how the priority system may be illustrated.

6.2 ACTIVATION/DEACTIVATION

6.2.1 Definitions

6.2.1.1 Terminal Side equipment States

6.2.1.1.1 STATE F1: The condition that the terminal is not aware that it is connected to a physical interface. This may be cuased by physically unplugging the terminal or powering the terminal down so that it is no longer monitoring the interface.

6.2.1.1.2 STATE F2: After the terminal becomes aware that it is attached to an interface but has not determined the type of signal that is being transmitted from the network side equipment (if any).

6.2.1.1.3 STATE F3: Deactivated state of the physical protocol. Neither network side equipment nor terminal side equipment is transmitting.

6.2.1.1.4 STATE F4: When the terminal side equipment is requested to initiate activation it transmits a signal (INFO 1) and waits for a response from the network side equipment.

6.2.1.1.5 STATE F5: When the terminal side equipment receives an activation signal from the network side equipment (INFO 2) it responds with a signal (INFO 5) and waits for normal frames from the network side equipment (INFO 4).

6.2.1.1.6 STATE F6: This is the normal active state with the protocol activated in both directions. Both the network side equipment and the terminal side equipment are transmitting normal frames.

6.2.1.2 Network Side Equipment States

6.2.1.2.1 STATE G1: The deactive state; the network side equipment is not transmitting.

6.2.1.2.2 STATE G2: A partially active state the network site sends INFO 2.

6.2.1.2.3 STATE G3: The normal active state where the network side equipment to terminal side equipment direction is active. The terminal side to network side direction may or may not be active. The network side may deactivate or maintain the active state when the terminal side stops transmitting. The choice to eventually deactivate is completely up to higher layerprotocols within the network side.

6.2.2.3 Activate Primitives

The following primitives should be used in the activate procedures. For use in state diagrams, etc., abbreviations of the primitive names are also given.

Activate Request AR

Activate Indicate AI

6.2.2.4 Deactivate Primitives

The following primitives should be used in the deactivate procedures. For use in state diagrams, etc., abbreviations of the primitive names are also given.

Deactivate Request DR

Deactivate Indicate DI

NOTE: Implementation of primitives in network and terminal equipment is not for recommendation.

6.2.2.5 Time Outs

Maximum times need to be specified for terminal side equipment response to incoming activation requests and for network side equipment response to activation signals. These values are subject to further study.

6.2.2 SIGNALS

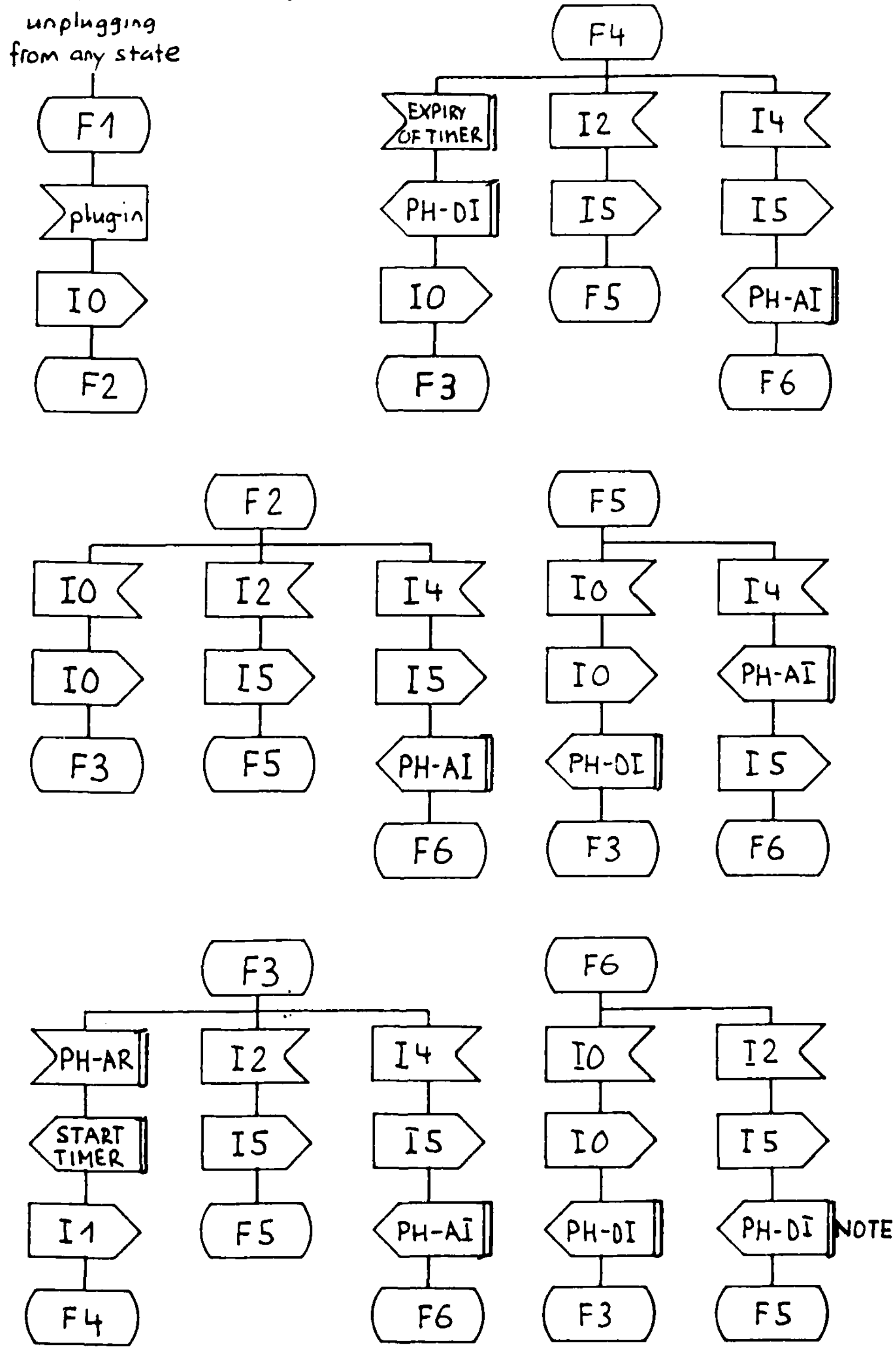
The identification of specific signals across the S/T Reference Point are given below. Also included is the coding for these signals

Signals from ET to TE		Signals from TE to ET	
Info 0	no signal	Info 0	no signal
		Info 1	A continious signal with the following pattern: positive zero, negative zero six "ones" bit rate = 192 kbits/sec
Info 2	Frame with all bits of B,D and Echo channels set to zero, according to the normal framing rules.		
		Info 3	Not used in the procedures at this time. See Appendix 10 of report for definition and discussion on use of Info 3
Info 4	Frames with operational data on B,D and Echo Channels		
		Info 5	synchronized frames with operational data on B and D channels

Definition of info signals

CCITT
STUDY GROUP XVIII
Geneva, 21.11 - 2.12.1983

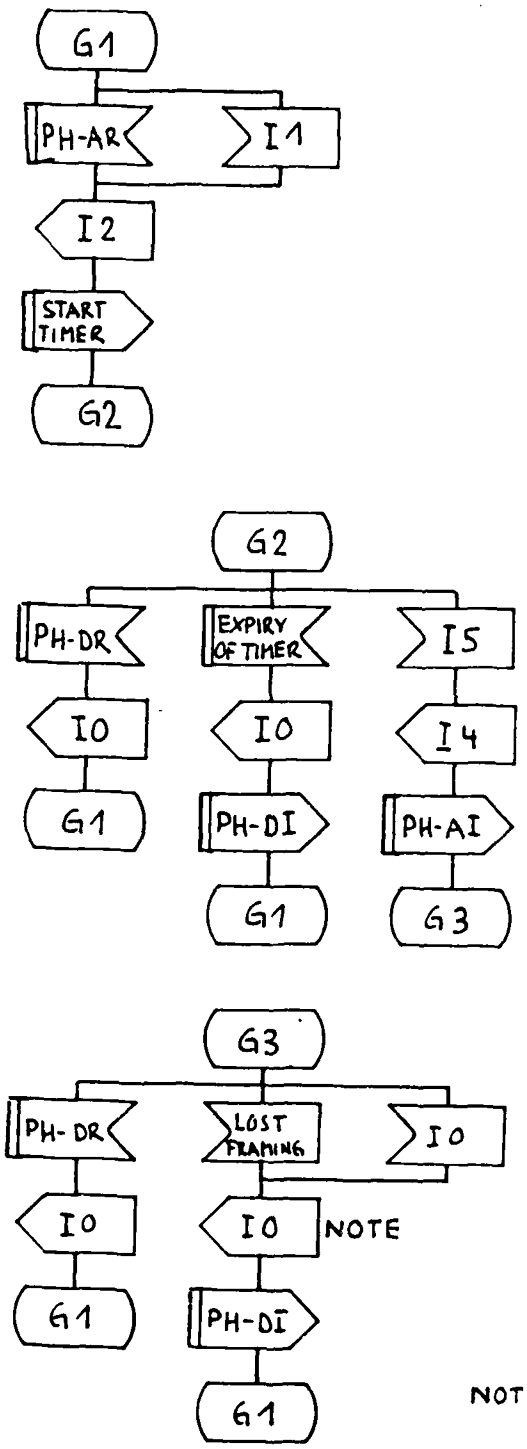
Temporary Document No. 40-E
Replacing 7, 8, and 17 in TD-36



NOTE: WT XVIII/2 proposes to send an error indication MPH-EI instead of a PH-DI

FIGURE /I.431 ACTIVATION/DEACTIVATION LAYER 1 PROCEDURES AT THE USER SIDE

2



NOTE When I0 has to be transmitted is a function of the specific Network

FIGURE /I.431 ACTIVATION/DEACTIVATION LAYER 1 PROCEDURES AT THE NETWORK SIDE

6.3 Frame alignment procedures

The frame alignment procedures make the use of the fact that the framing signal is defined to be a line code violation; this allows a rapid reframing procedure to be defined.

According to the coding rule, both the framing signal and the following binary zero data bit (in the same frame) produce a code violation. In the event, that there are not binary zero data bits in the same frame then, the auxiliary framing (F_A) and N bits (NT to TE direction) are coded as a pair, such that N is the binary opposite of F_A. This will ensure that there is always a code violation at 14 bits or less from the framing bit (F). In the TE to NT direction the F_A and L bits are coded according to the normal coding rule.

6.4.1 Frame alignment procedure in the direction NT to TE

Frame alignment, on initial activation of the TE shall comply with the procedures defined in section 6.2.

6.4.1.1 Loss of frame alignment may be assumed when a time period equivalent to two 48 bit frames has elapsed without having detected valid pairs of code violations obeying the ? 14 bit criterion as described above. The TE shall cease transmission immediately.

6.4.1.2 Frame realignment may be assumed to occur when 3 consecutive pairs of line code violations 1) obeying to ? 14 bit criterion have been detected.

If it is not possible to achieve frame realignment within a time period equivalent to 9 X 3 frames, the TE shall continue to transmit INFO Q (see note 2)

Notes : 1 - The reframing procedure does not depend on the polarity of the code violations, i.e. it is not sensitive to wiring polarity

2 - Other actions, e.g. informing the management entity requires further study

3 - The value of ? is dependent on performance and requires further study.

6.4.2 Frame alignment in the direction TE to NT

In the direction TE to NT the F_A and L bits are always coded according to the coding rule such that binary F_A and L are equal. The criterion of a code violation at 13 bits or less from the framing bit (F) shall apply. The NT shall assume loss of frame alignment if a time period equivalent to two 48 bit frames has elapsed since detecting cc· ·utive violations according to the 12 bit criterion. On detection of loss of frame the NT shall continue transmitting towards the TE. The NT shall assume that frame alignment has been regained when those consecutive pairs of code violations obeying the 12 bit criterion have been detected.

If after Q* attempt to realign the NT is still unable to regain frame alignment the NT shall send Info 0 towards the TE and inform layer 2 by means of the PH deactivate Indication (Note: the implementation of this primitive depends on the NT-ET transmission system which is not subject to CCITT Recommendations).

6.4.3 Multiframing

The use of multiframing and the definition of multframe structures requires further study. **

Note that the coding of F_A and N bits as defined in section 6.4 may be used to provide a multiframe capability and/or other functions yet to be defined.

** Pending such study, the F_A bit will be set to binary on both directions of transmission.

---

*) Note: the value of Q is network dependent and will not be specified.

6.4 Frame alignment procedures

The frame alignment procedures make use of the fact that the framing signal is defined to be a line code violation, this allows a rapid reframing procedure to be defined.

According to the coding rule, both the framing signal and the following binary zero data bit (in the same multiframe) produce a code violation. In the event that there are no binary zero data bits in the same multiframe then the auxiliary framing bit Fa, which occurs 13 bit positions after the frame alignment signal, and is coded as a binary zero, will produce a code violation.

6.4.1 Frame alignment procedure in the direction NT to TE

A terminal shall search for line code violations. Having detected a violation, a count of the number of bits until the next violation shall be initiated. If the count is 13 or less (the distance between the framing and auxiliary framing bits) then the first violation shall be taken to indicate the true framing position. For any other value of the counter it shall be assumed that true framing has not been achieved and the search shall continue.

Note that this reframing procedure does not depend on the polarity of the code violations, i.e. the system is not sensitive to wiring polarity.

In the instance of loss of frame alignment an ERROR primitive shall be passed from layer 1 to layer 2.

6.4.2 Frame alignment procedure in the direction TE to NT

The same alignment procedure shall be used as in the NT to TE direction. It should be noted however that for some applications, e.g. on a short passive bus where the round trip delay is less than one bit, it is possible to use a receiver in the NT with fixed timing.

6.4.3 Multiframing

Multiframing is for further study. (Note that it is intended that, in the direction TE to NT, the Fa bit may only be required in one out of four frames. The bits in the 14th bit position of the other frames may be used for other purposes, yet to be defined. Such use would require a multiframe capability.)

7. Layer 1 maintenance

For further study

8. Electrical characteristics

8.1 Bit rate

8.1.1 Nominal rate .... 192 kbit/s

8.1.2 TE tolerance (free running) .... ±100 ppm

8.1.3 NT1 or NT2 (free running) .... ±32 ppm

DRAFT RECOMMENDATION I.431

8. Electrical characteristics

8.1 Bit rate

8.1.1 Nominal rate .... 192 kbit/s

8.1.2 Tolerance (free running mode) + 100 ppm

8.2 Jitter and bitphase relationship between TE input and output

8.2.1 Test configuration

The jitter and phase deviation measurements are carried out with four different waveforms at the terminal input in accordance with following configurations:

i) point-to-point configuration with 6 dB cable attenuation measured between two terminating resistors, as measured at 96 kHz

ii) short passive bus with 8 clustered terminals at the end (high capacitance cable)

iii) short passive bus with 1 terminal near to NT and 7 clustered terminals at the end (low capacitance cable)

IV) back to back condition with 1 terminal (without cable)

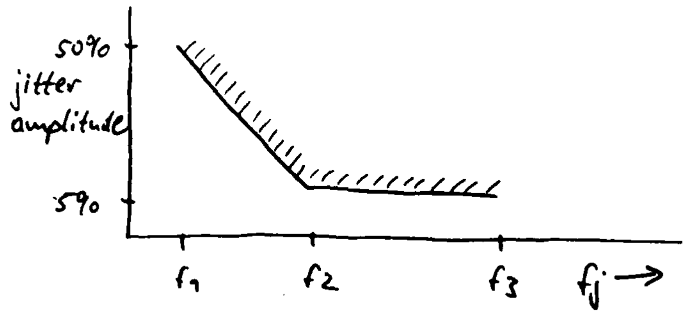
Examples for waveforms i, ii, iii and a test configuration which can generate these signals are given in Annex 2.

Other possible test conditions and the parameters of the artificial line have to be identified and are for further study.

8.2.2 Timing extraction jutter due to TE ± 7 % of a bit period, measured with high pass filter with a cut off frequency of 30 Hz under test conditions described in 8.2.1 with all possible test patterns.

Worst case test pattern is for further study.

8.2.3 Phase deviation between TE input and output -7 ... +15% of a bit period using as reference crossings of zero volt between framing pulses and associated balance pulses. The phase deviation has to be measured under test conditions described in 8.2.1 with all possible test patterns. Additionally, the test signal at the output of the pattern generator has to be modulated with sinusoidal jitter as given below.



Worst case test pattern is for further study.

Note 1 - The values of the frequencies f_1, f_2 and f_3 are for further study.

8.3 NT1 or NT2 jitter characteristics

8.3.1 Maximum output jitter (p-p) 5% of a bit period measured with high pass filter with a cut off frequency of f_2 Hz.

8.4 Termination of the line

Terminating resistor (see figure 1/I.431) p. 12	100 Ω ±5%

8.5 Transmitter output characteristics

8.5.1 Transmitter output impedance

8.5.1.1 NT transmitter output impedance

In all states including the inactive state at interface point I_B (see figure 1/I.431)	To exceed template (Figure 8.5.1.1)

Note : In some applications the terminating resistor can be combined with the NT (see fig. 1/I.431, point b), the resulting impedance is the combination of impedance needed to exceed the template and of the termination.

8.5.1.2 TE transmitter output impedance

In all states including the inactive state at interface point I_A (see figure 1/I.431)	To exceed template (Figure 8.5.1.2)

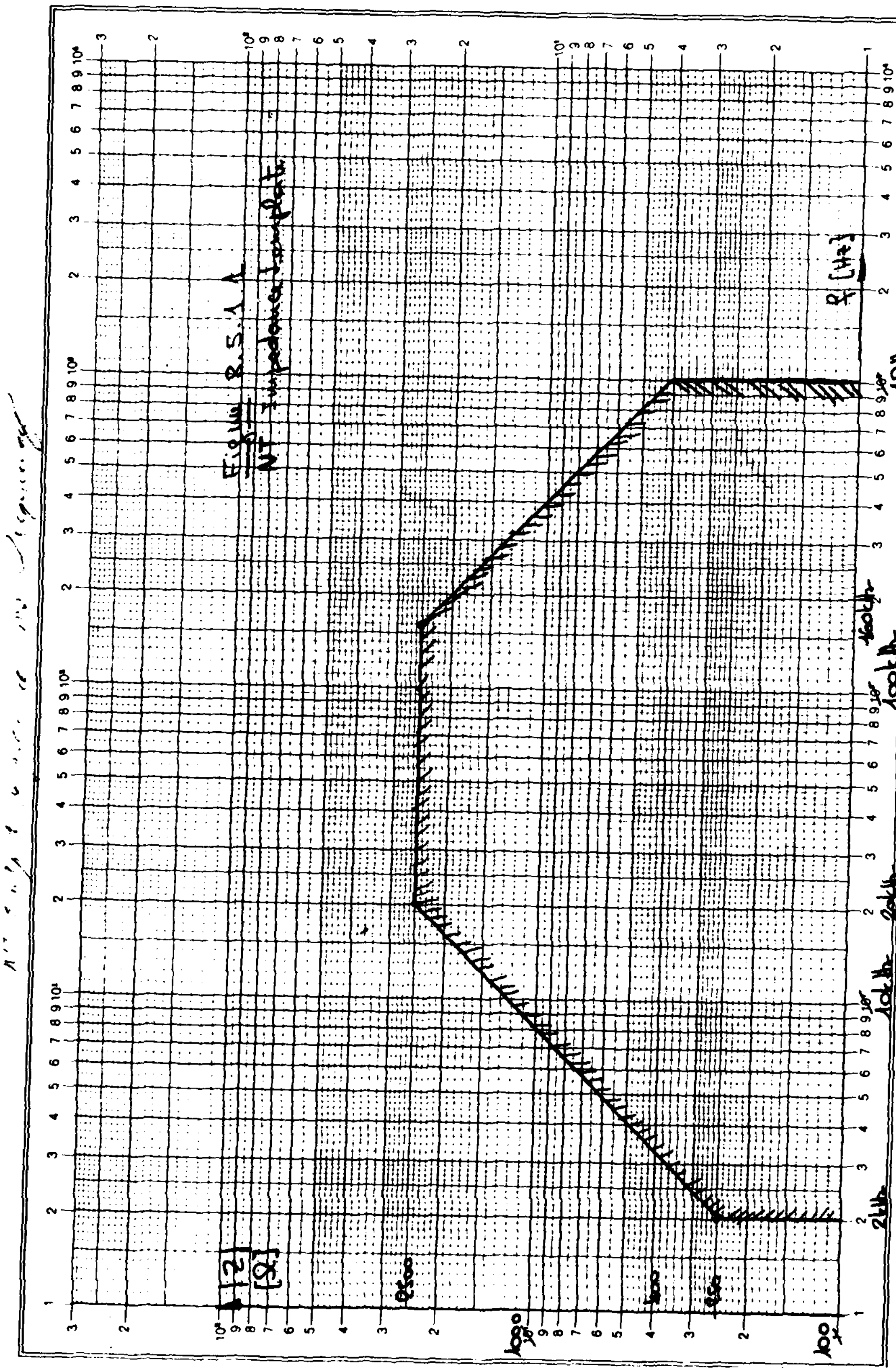


Figure 8.5.1 A
NF impedance template
f [Hz]
[Ω]
2kHz
10kHz
20kHz
100kHz
160kHz
1MHz
Logar. Teilung / Division 1-300 u. 1-10000
Einheit / Unité 62,5 mm
Ed. Aerni-Leuch, Bern, Nr. 551

-5-

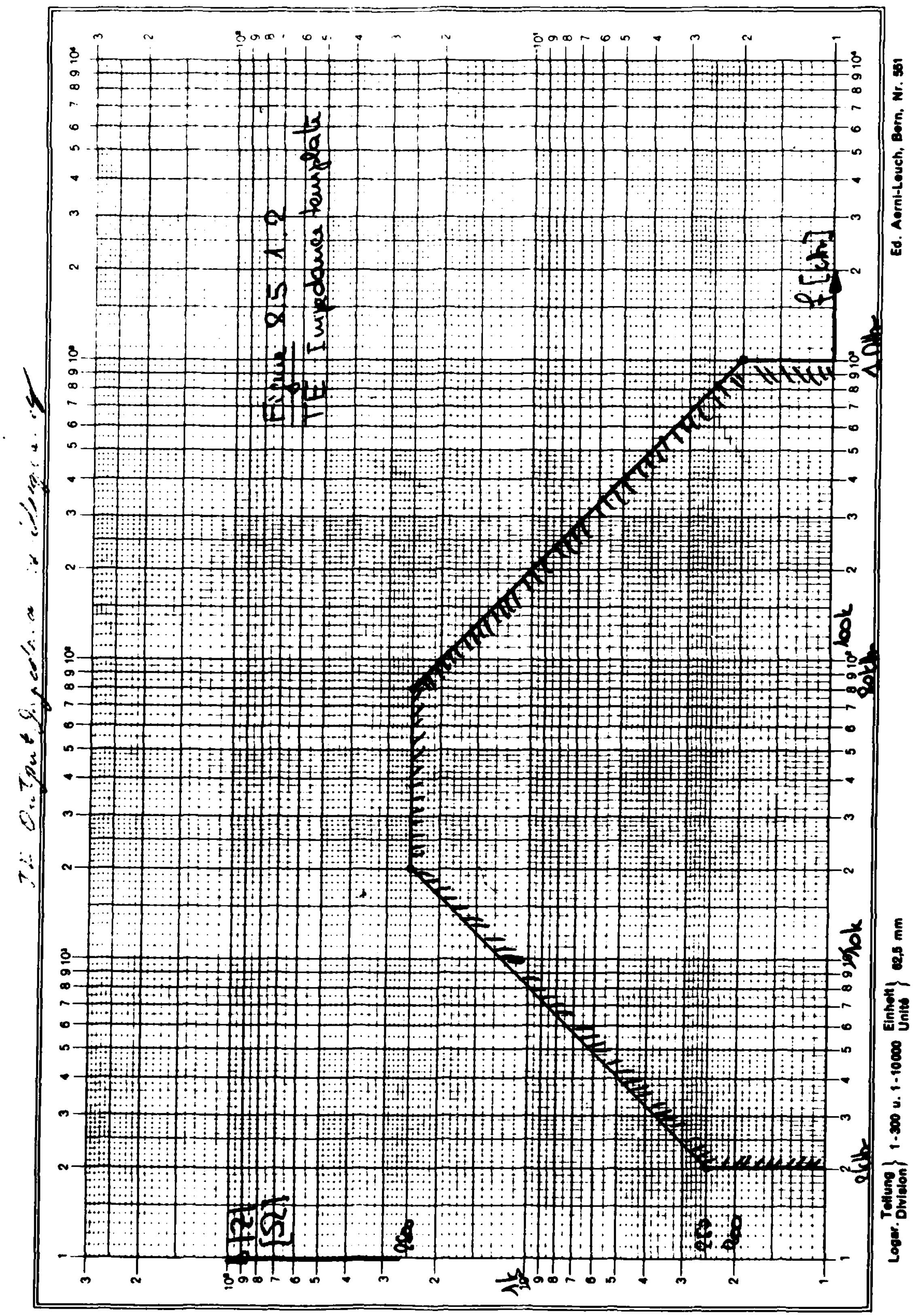


Figure 8.5.1.2
TE Impedance template
Ed. Aerni-Leuch, Bern, Nr. 551
Loga. Teilung Division 1-300 u. 1-10000 Einheit Unité 62,5 mm

8.5.2	Test load impedance .... 50 ohms (unless otherwise indicated)	
8.5.3	Pulse shape and amplitude (logical "0")	
8.5.3.1	Pulse shape ....within mask Figure 8.3.1	
8.5.3.2	Nominal pulse amplitude (zero to peak) 750 mV A positive + at the output parts of the NT and TE is defined as a positive polarity from 3-4 and 5-6 of the interface respectively.	
8.5.4	The pulse unbalance, the difference in $\int U(t)dt$ for positive pulses and $\int U(t)dt$ for negative pulses $\leq 5\%$	
8.5.5	Voltage on other test loads (other than 50 Ω)	
8.5.5.1	Overvoltage with 400 Ω load	within mask Figure 8.5.5
8.5.5.2	Voltage with 5, 6 Ω load	within mask Figure 8.5.5
8.5.6	Unbalance about earth (measured by considering the power feeding and two 100-ohm-terminations at each port)	
8.5.6.1	Longitudinal conversion loss (LCL) in accordance with G.117, item 4.2.3, (see figure 8.5.6.1) a) 10kHz $\leq$ f < 300 kHz $\geq$ 60 dB b) above 30 kHz up to 1 MHz decreasing with 20 dB/decade	
8.5.6.2	Output signal balance in accordance with G.117, item 4.3.1 (see figure 8.5.6.2) 100 kHz 60 dB decreasing with 20 dB/decade up to 1 MHz	

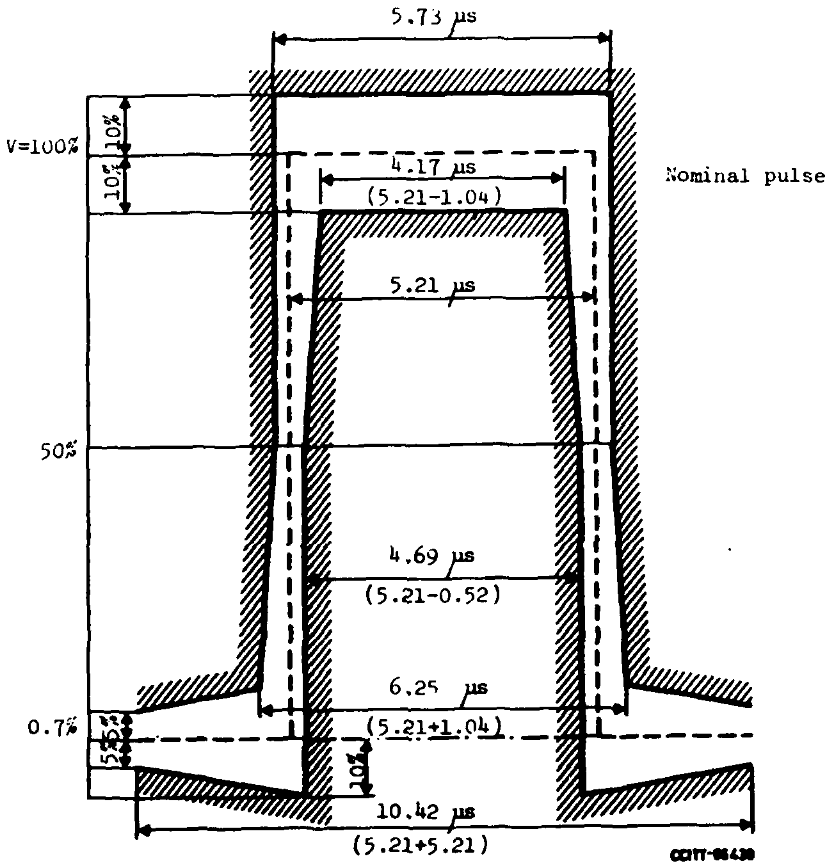


Figure 8.5.3.1 - Transmitter output pulse mask

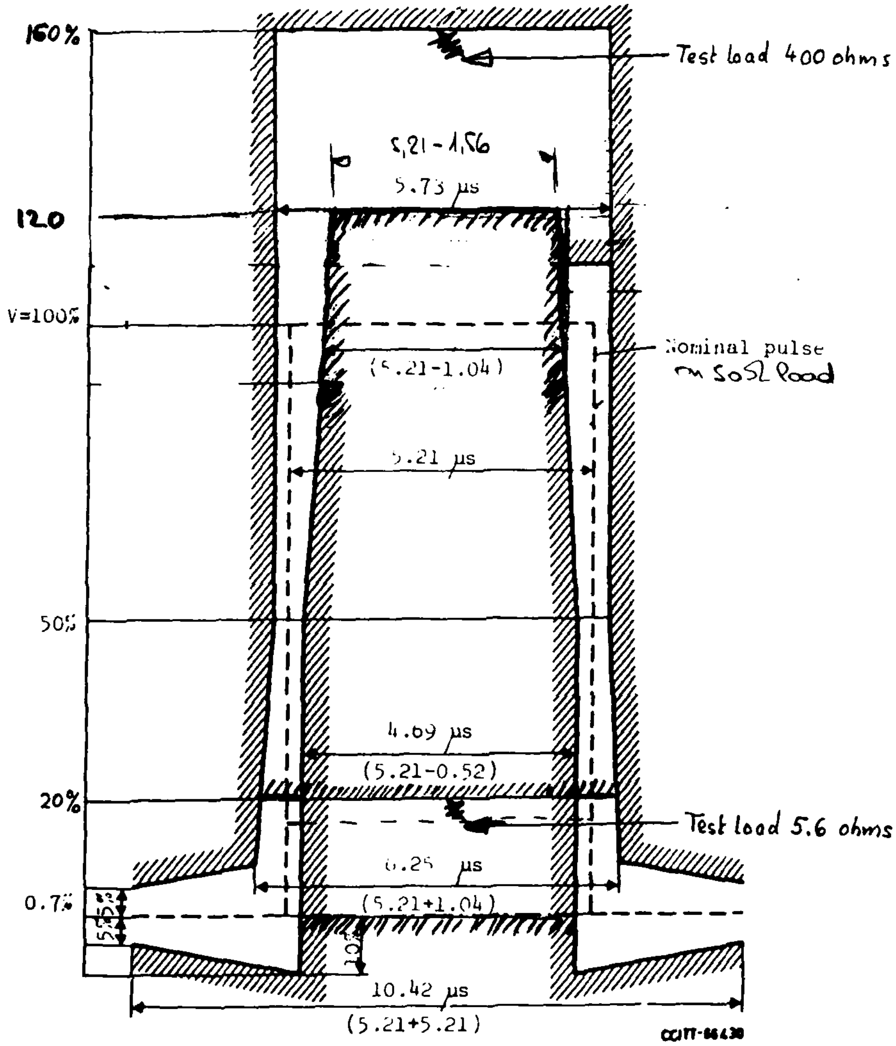
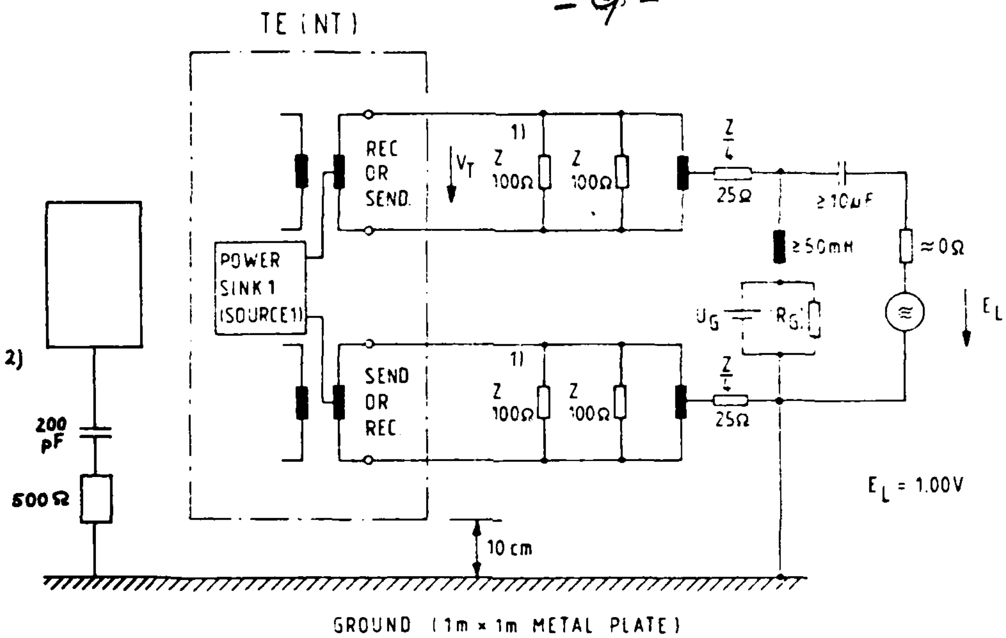


Figure 8.~~4.3.4~~ -
8.5.5 Voltage on other test loads



$$\text{LONGITUDINAL CONVERSION LOSS (LCL)} = 20\left(\log_{10}\left|\frac{E_L}{V_T}\right|\right)\text{dB}$$

THE VOLTAGES V_T AND E_L SHOULD BE MEASURED WITHIN THE FREQUENCY RANGE FROM 10KHZ UP TO 1MHZ BY APPLYING A SELECTIVE TEST EQUIPMENT.
THE MEASURING IS TO CARRY OUT IN THE STATE

- DEACTIVATED (REC., SEND.)
- PARTIALLY ACTIVATED (REC., SEND.)
- ACTIVATED (REC.)

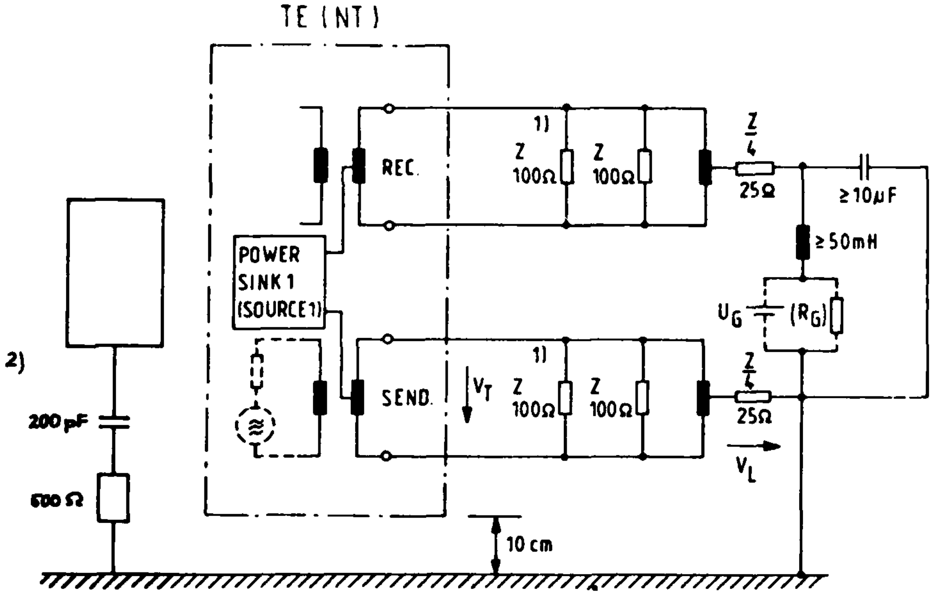
NOTE 1)
THE SHOWN RESISTOR MUST BE OMITTED IF THE TERMINATION IS ALREADY BUILT-IN THE TE(NT).

NOTE 2)
HANDIMITATION – Equivalent to Z of hand

RD.07

RECEIVER INPUT OR TRANSMITTER OUTPUT
UNBALANCE ABOUT EARTH

FIGURE 8.56.1



GROUND (1m × 1m METAL PLATE)

$$\text{OUTPUT SIGNAL BALANCE} = 20\left(\log_{10}\left|\frac{V_T}{V_L}\right|\right)\,\text{dB}$$

THE VOLTAGES V_T AND V_L SHOULD BE MEASURED WITHIN THE FREQUENCY RANGE FROM 10KHZ UP TO 1MHZ BY APPLYING A SELECTIVE TEST EQUIPMENT. THE MEASURING IS TO CARRY OUT IN THE ACTIVE STATE BY MEANS OF A SUITABLE SIGNAL PATTERN

NOTE 1)
THE SHOWN RESISTOR MUST BE OMITTED IF THE TERMINATION IS ALREADY BUILT-IN THE TE(NT).

NOTE 2)
HANDIMITATION

TRANSMITTER OUTPUT
UNBALANCE ABOUT EARTH

FIGURE 8.56.2

8.6 Receiver input characteristics

8.6.1 Receiver input impedance

8.6.1.1 TE receiver input impedance

In all states including the inactive state at interface point I_A (see fig. 1/I.431) — To exceed template (Fig. 8.5.1.2)

8.6.1.2 NT receiver input impedance

In all states including the inactive state at interface point I_B (see fig. 1/I.431) — To exceed template (fig. 8.5.1.1)

Note : In some applications the terminating resistor can be combined with the NT (see fig. 1/I.431 point B) the resulting impedance is the combination of impedance needed to exceed the template and of the termination.

8.6.2 Receiver sensitivity and noise immunity

The measurement method requires further study.

8.6.3 NT receiver input delay characteristics

8.6.3.1 Point-to-point requirements .... up to 6 bits
(Round trip delay)

8.6.3.2 Simple (short) passive bus requirements .... 0 - 2.5 µS
(Round trip and differential round trip delay)

8.6.3.3 Branched star (or extended bus) ....
Round trip delay .... up to 6 bits
Differential round trip delay .... 0 - 0.5 µS

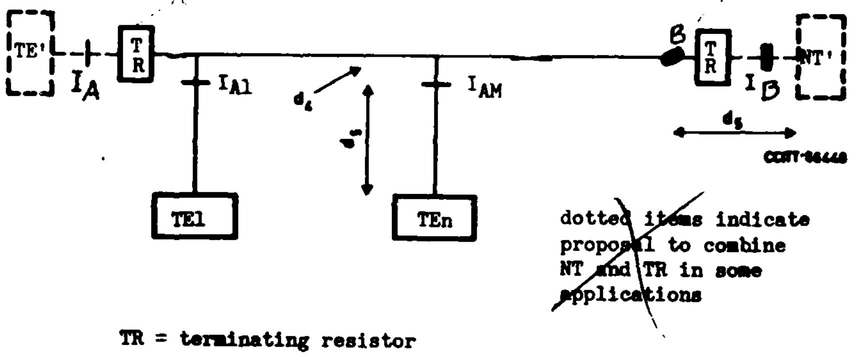
8.6.4 Unbalance about earth
Longitudinal conversion loss measured in accordance with G.117, item 4.1.3, by considering the power feeding and two 100-ohm-terminations at each port.
(See figure 8.5.6.1)
a) 10 kHz ≤ f < 300 kHz — ≥60 dB
b) above 300 kHz up to 1 MHz — decreasing with 20 dB/decade

8.7 Isolation from external voltages — Further study

8.8 E.M.I. Generation — Further study

10. Mechanical characteristics

For further study.



TR = terminating resistor

Figure 1/I.431 - Reference configuration at in premises location.

Figures 2, 3, 4 and Appendix 1 unchanged

9. Power feeding

9.1 Reference configuration

The reference configuration for power feeding, based on an eight pins interface connector is described in Figure 4/I.431. The use of four access leads (3, 4, 5, 6) is mandatory, the use of the remaining four (1, 2, 7, 8) is optional.

This reference configuration allows unique physical and electrical characteristics, for the interface at reference points S and T, which are independent of the choice of internal or external power sources arrangements.

Power source 1 may drive its power from the network and/or locally (including batteries). Power source 2 derives its power locally (including batteries).

9.1.1 Functions specified at the eight access leads

The eight access leads, for TE and NT should be applied as follows:

a) access leads 3-4 and 5-6 whose provision is mandatory, are strictly reserved for the bi-directional transmission of the digital signal and may provide a phantom circuit for power transfer;

b) access leads 1-2 and 7-8, whose provision for power feeding is optional may be used for additional power transfer from NT to TE;

c) access leads 1-2 and 7-8, whose provision is optional, may be used for power transfer in TE-TE interconnection. This characteristic of the power on these leads are not the subject of a CCITT Recommendation.

Note 1 : Power source 2 - Provision of this source is subject to the decision of individual administrations.

Note 2 : Where the power source 1 is provided, the minimum powers available from this source on the phantom are to be specified during the normal condition. The provision of power greater than the minimum is the responsibility of the individual Administrations.

Note 3 : Power sink 2 is optional.

Note 4 : Power source 3 is not subject to CCITT Recommendations.

Note 5 : Power sink 1 is optional. Administrations may limit the use of the power from the phantom to those terminals capable of providing a minimum service.

Note 6 : The numbering of leads in Figure 4/I.431 does not imply any assumption on pin allocation or physical connectors.

Note 7 : Maintenance of polarity, on a wired pair cannot be guaranteed in all cases. This must be taken into consideration for terminals drawing power from 7-8 access leads.

Note 8 : Power source 1 may not always be provided.

Note 9 : It should be noted that a terminal that is to be portable (e.g. from network-to-network, country-to-country) can not rely exclusively on phantom power for its operation.

9.2 Power available from NT

Two different situtations are identified relative to power feeding:

9.2.1 Minimum power, P_γ, available from source 1 on the phantom using local mains power or an equivalent level of power from the network (or a combination of local and network power). The provision of power P_γ will be the responsibility of individual administrations.

9.2.2 a) minimum power, P_α , available from source 1 on the phantom (eg when mains powering is unavailable or not provided at the NT). The value P_α , should be 400 mW (1). This may be the only available power in case of emergency.

b) emergency condition. The emergency condition exists when the NT looses power from the mains. When the NT is only able to deliver P_α , this condition is indicated by the NT in changing the polarity of the voltage over the phantom circuit. In this condition only emergency functions of terminals are allowed to draw power from the phantom circuit.

Note (1) : This value of P_α is provisional and a lower value (eg : 250 mW) is subject to further study over the next study period.

9.3 Power available at TE - Phantom mode (access lead 3.4 and 5.6)

9.3.1 Voltage

The voltage at the input to the TE will be :

a) normal conditions, X volts $^{+5}_{-y}$ %

b) emergency conditions, - (X volts $^{+5}_{-z}$ %)

(For X, a choice should be made between 24v or 40v.)

(The tolerances, y and z are for further study)

(The value of 5% is based on 40v for X, and might be higher for 24v [Max safe voltage is 42.5v.])

9.3.2 Current

The maximum current available at the input to a TE in order to remain above the minimum voltage (X volts-z%) under emergency conditions is I ma.

(The value of current I is for further study)

9.4 Current transient

The rate at change of current drawn by a TE (when connected or as a result of a polarity change for emergency conditions) shall not exceed R ma//us.

(The value R is for further study)

9.5 Power down mode consumption

The power down mode consumption of a TE must be less than W watts (W should be choosen in the range of 0 to 50 mW).

Title of 4/I.431 is "Reference configuration for power feeding under normal operating mode.

Add "RECEIVE" at NT terminals 5-6 and "TRANSMIT" at NT terminals 4-3.

Appendix 1

Elements for layer to layer communications

1. General

1.1 Overview definition of primitives

All communications between layers are accomplished by primitives. Primitives consist of command and their respective responses associated with the services requested of a lower layer. The general syntax of a primitive is :

XX -- Generic Name -- Specific Name : PARAMETERS

The XX designates the layer providing the service. For this Recommendation XX has the values DL for Data Link layer and PH for Physical Layer. The generic name specifies the action that the addressed layer should perform. The primitive generic names that are used in this Recommendation are shown in the first column of Table 1/I.430 (431). The specific name indicates the direction of the primitive flow. In Table 1 the specific primitive names that are used in this Recommendation label the next four columns. The specific name REQUEST is used when a higher layer is requesting a service from its next lower layer. The specific name INDICATION is used when the layer providing the service wants to notify the next higher layer of activity associated with the generic name. The specific name RESPONSE is used by a higher layer to acknowledge a receipt of an INDICATION primitive. The specific name CONFIRM is used by the layer providing the requested service to confirm that the action has been completed. The sequence of events is shown in Figure 1.

Note that not all generic names contain all four specific names. The parameters associated with each primitive generic name are shown in Table 2/I.431.

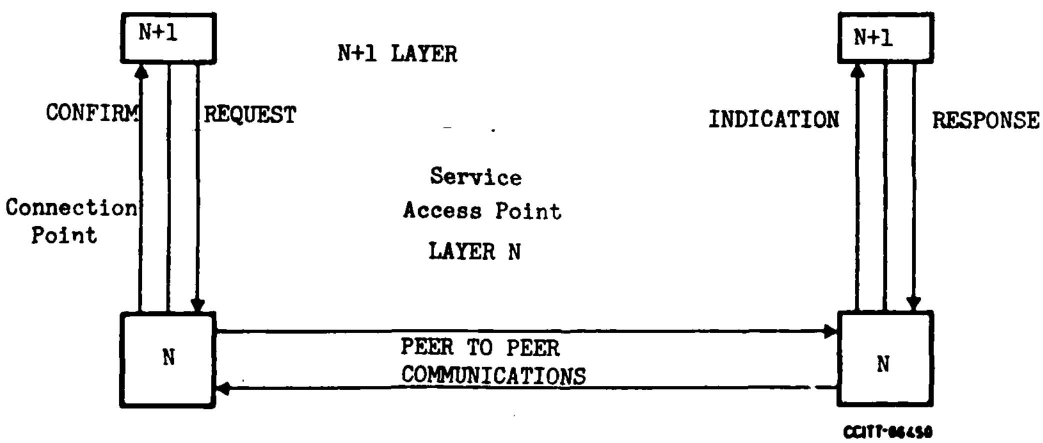


Figure 1

ANNEX 1

(to Recommendation I.431)

Wiring configurations and interconnecting media characteristics used as a basis for electrical characteristics

1. Introduction

1.1 In section 4 of Rec I.431 two major wiring arrangements are identified. These are a point-to-point configuration and a point-to-multipoint configuration using a passive bus.

While these configurations may be considered to be the limiting cases for the definition of the interfaces and the design of the associated TE and NT equipments, other significant arrangements should be considered.

1.2 The values of overall length and delay assumed for each of the possible arrangements are indicated below

1.3 Figure 1/I.431 of the Recommendations is a composite of the individual configurations. These individual configurations are shown in this Annex.

2. Wiring configurations

2.1 Point-to-point

This configuration provides for one transmitter/receiver only at each end of the cable (see Fig. A.2.1. It is therefore necessary to determine the maximum permissible attenuation between the ends of the cable, to establish the transmitter output level and the range of receiver input levels. In addition, it is necessary to establish the maximum round trip delay for any signals which must be returned from one end to the other within a specified time period (limited by echo D bits)

A general objective for the operational distance (measured at 96 kHz) between TE and NT or NT1 and NT2 is 1.0 km. It is agreed to satisfy this general objective, that a maximum cable attenuation of 6 dB and a round trip delay of 6 bit periods (at 192 kbit/s) are the objectives for the definition of the electrical characteristics. It should be noted that an adaptive timing device at the receiver is required at the NT to meet these limits.

By this type of wiring configuration it is also possible to provide point-to-multipoint mode of operation at Layer 1. One example (active bus) is shown in Figure A.2.2.

2.2 Point-to-multipoint

2.2.1 In addition to the "short passive bus" identified in section 2 of the Recommendation, other configurations, such as an "extended passive bus" may be used to provide for point-to-multipoint type of configuration.

2.2.2 Short passive bus (Figure A.2.3)

An essential configuration to be considered is a passive bus in which the TE devices may be connected at random points along the full length of the cable. Because this means that the NT receiver must cater for pulses arriving with different delays from various terminals, a length limit for this configuration is a function of the maximum round trip delay and not the attenuation. An NT receiver with fixed timing can be used if the round trip delay is restricted to 2.5 uses. This relates to a maximum operational distance from the NT in the order of 100 - 150 metres. It should be noted that the TE connections act as stubs on the cable thus reducing the NT receiver margin over that of an equipment point-to-point configuration. A maximum of 8 stubs of 10 metres in length are to be accommodated.

2.2.3 Extended passive bus (or branched star) (Fig. A.2.4)

A configuration which may be used at an intermediate distance between 100 metres and 1.0 km is known as the extended bus. It takes advantage of the fact that terminal connection points are restricted to a signal grouping at the far end of the cable from the NT. This places a restriction on the differential distance between TE's. The objectives for this configuration are a total length of 500 m and a differential distance between terminal connection points of 35 metres.

The achievable limits for this configuration would be a compromise based on the limiting receiver characteristics proposed for the other two configurations 2.2.1 and 2.2.2.

3. Interconnecting media characteristics

These characteristics have been used for the derivation of the distances indicated in the wiring configurations. They are also necessary for the determination of the sitnal characteristics at the receiver input in the different configurations.

The most important parameters directly related with the characteristics of the interface are indicated below:

Effective capabity (as defined in G.611)	C	$\leq$	120 nF/km		at	1 kHz
Magnitude of the Impedance	700	$\leq$	$\lvert Z \rvert$	150	at	100 kHz
Group delay	τ_o	$\leq$	9us/km		at	100kHz
Longitudinal conversion loss	LCL	$\geq$	43 dB		at	100 kHz
	(values are provisional)					

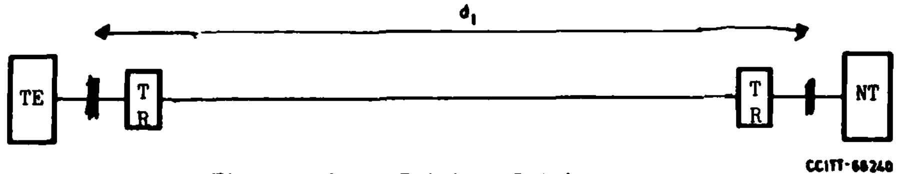


Figure A.2.1 - Point-to-Point

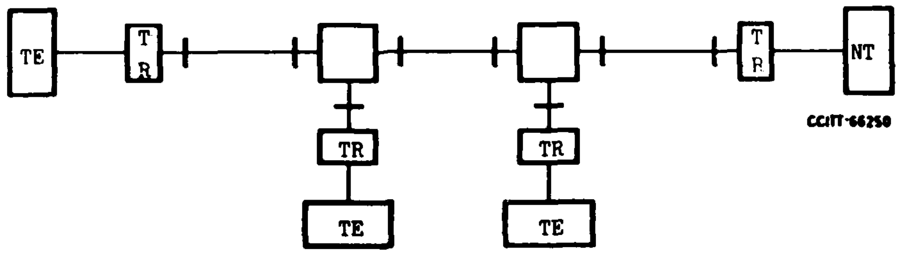


Figure A.2.2 - Active Bus

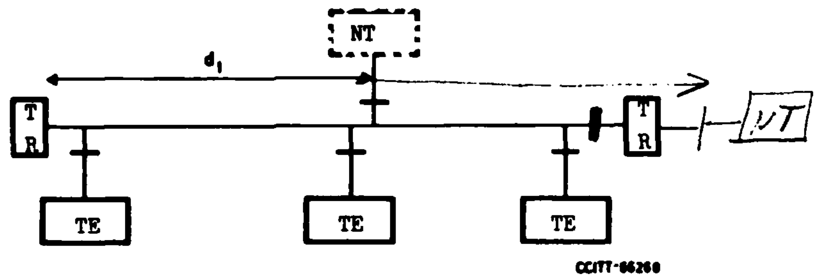


Figure A.2.3 - Short Passive Bus

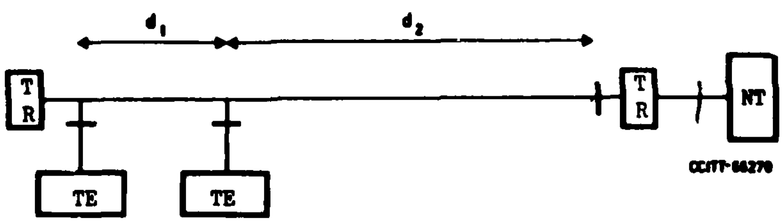


Figure A.2.4 - Extended Passive Bus

TR = terminating resistor

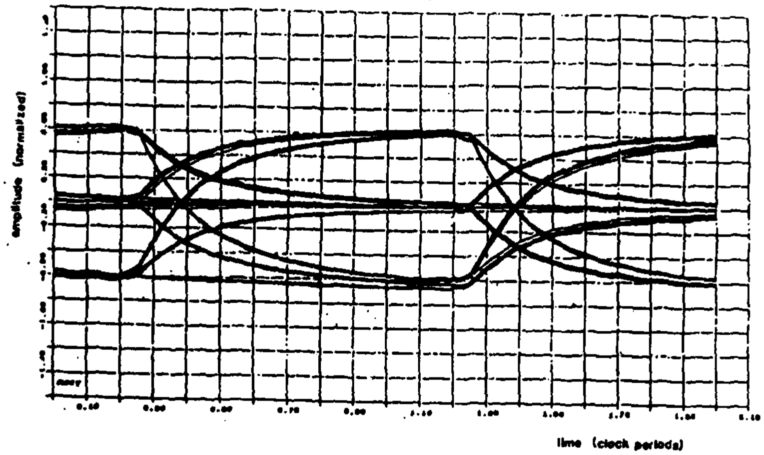
ANNEX 2 to draft Recommendation I.431

Jitter and bit phase relationship between TE input and output at So interface

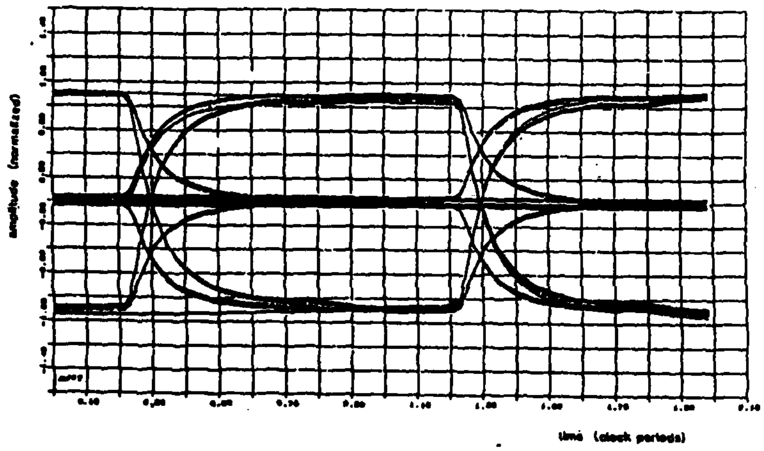
The fixed delay and jitter (p-p) due to TE represent one of the limiting factors of the length of the passive bus while the jitter is the most important parameter in point to point configuration.

In addition to the ideal waveform (see figure 8.5.3.1, p.7) the following three waveforms are used for the measurement :

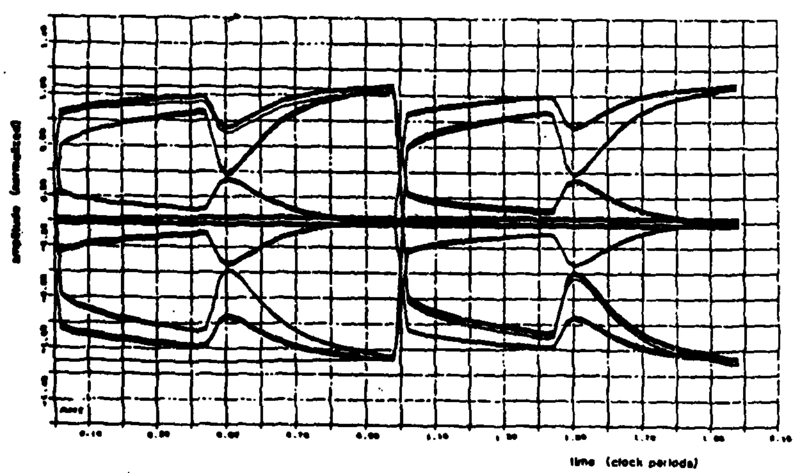
A possible way to generate these waveforms is illustrated in figure A.2.1



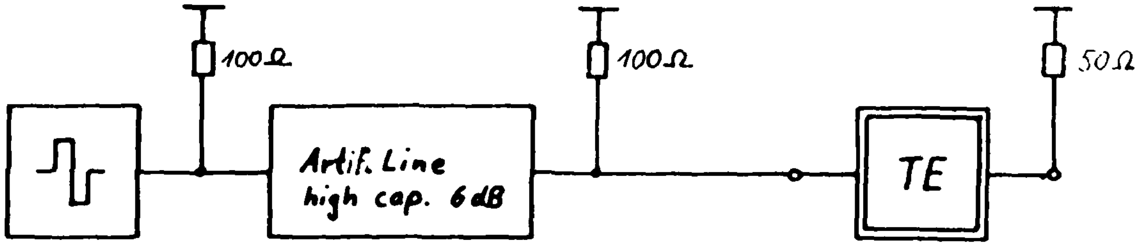
waveform i point to point (6dB)



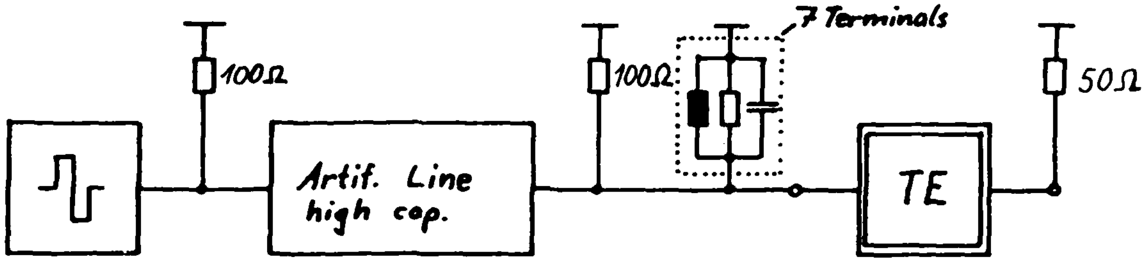
waveform ii short passive bus clustered TE at the end



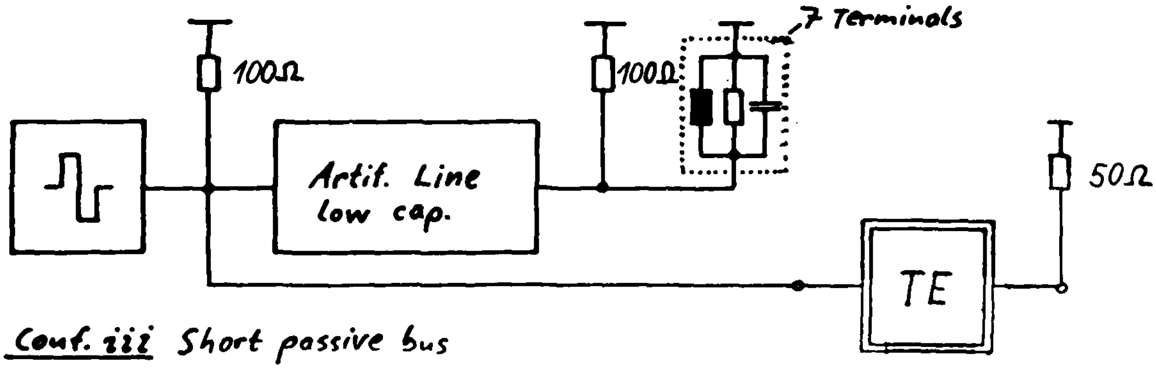
waveform iii short passive bus 1 TE near to NT, 7 TE at the end



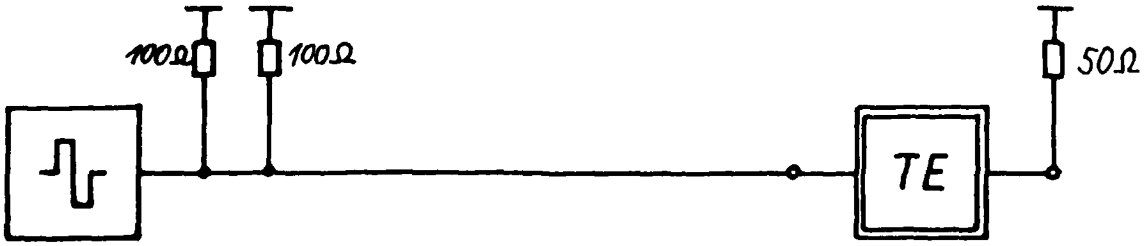
Conf. i Point to Point



Conf. ii Short passive bus



Conf. iii Short passive bus



Conf. iv Ideal test signal

Fig A 21

Phase deviation and Jitter Test Configurations

LAYER 1 PROCEDURES - NETWORK SIDE EQUIPMENT

State Name	DEACT	PEND ACT NETWORK	PEND ACT USER	ACT
INFO SENT INFO RECEIVED	0 0,5	2 0,1	2 1	4 0,5
State Number	G1	G2.1	G2.2	G3
Activate Request	G2.1;I2	–	–	–
Deactivate Request	–	G1;I0;DI	–	G1;I0;DI
INFO 0 (NOTE 1)	–	–	G1;I0	G1;I0;DI
INFO 1	G2.1;I2	–	–	ERR Note2
INFO 5	–	G3;I4;AI	G3;I4;AI	–
Time Out (NOTE 3)	/	G1;DI;I0	G1;DI;I0	/
Lost Framing	/	–;I0;DI	–;I0;DI	G1;I0;DI

NOTE 1: TIMER - SUBJECT FOR FURTHER STUDY. (NETWORK DEPENDENT AND MAY BE OF LONG DURATION)

Note 2:
Should notify layer 2 of failure(DI); send Info 2; go to state 1.

Note 3: Timer
Subject for further study.

States
G1 DEACT Physical Connection Inactive
G2.1 PEND ACT Activation Initiated (by network side equipment)
G2.2 PEND ACT Activation Initiated (by Terminal side equipment)
G3 ACT Physical Connection Active

ANNEX A TO I.431

LAYER 1 PROCEDURES - NETWORK SIDE EQUIPMENT

State Name	DEACT	PEND	ACT
INFO SENT INFO RECEIVED	0 0.5	2 0.1	4 0.5
State Number	G1	G2	G3
Activate Request	G2,I2		
Deactivate Request		G1:I0	G1:I0
INFO 0 (Note 1)			G1:I0
INFO 1	G2,I2		
INFO 5		G3;I4 ;AI	
Time Out (Note 3)		G1;0I ;I0	
Lost Framing (Note 1)			G1;I0 ;DI

Note 1: The time needed to react to lost framing or IØ is network dependent and may be of long duration.

Note 3: Value for Time is a subject for further study.

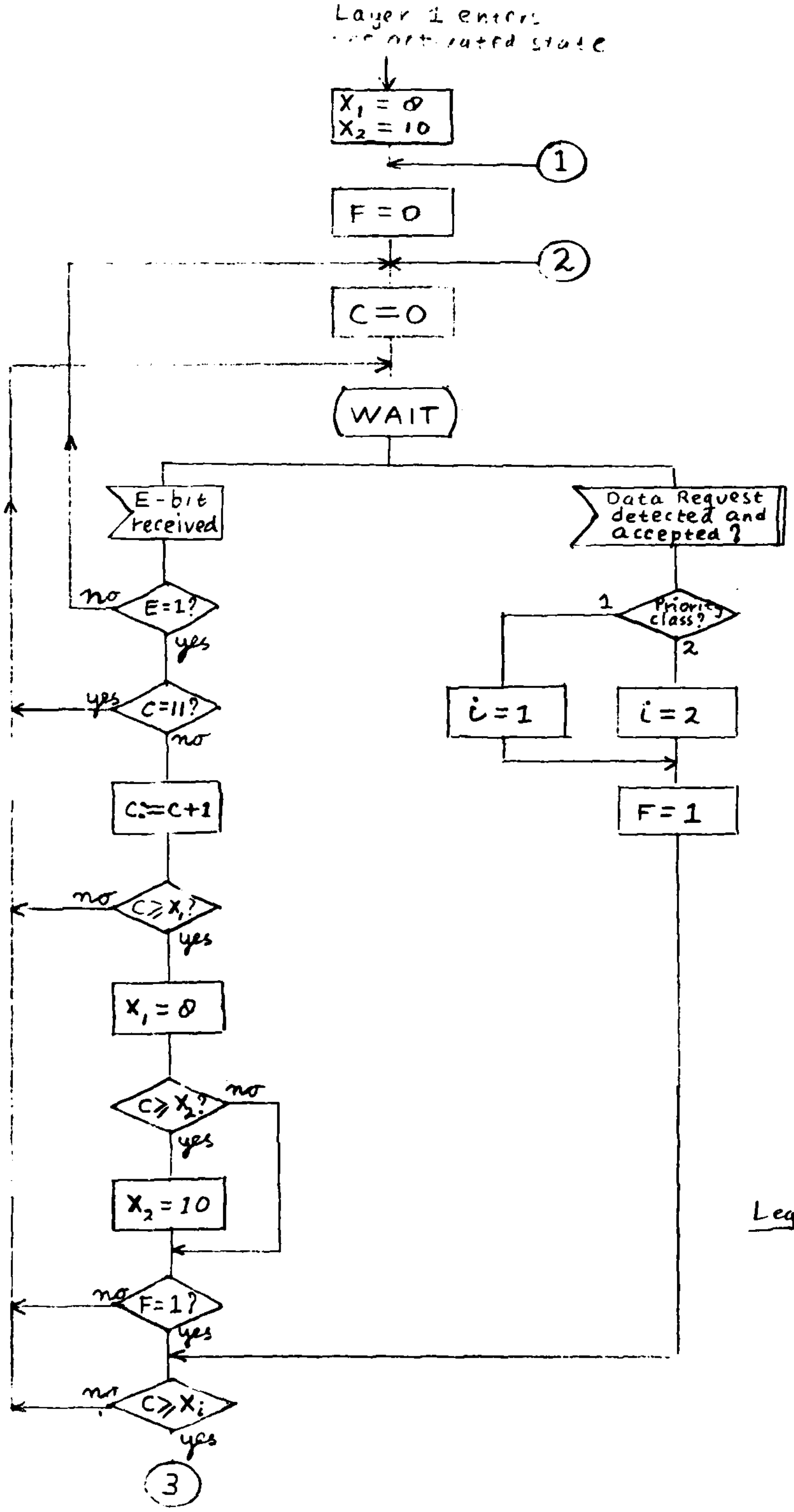
States

G1	DEACT	Physical Connection Inactive
G2	PEND ACT	Activation Initiated
G3	ACT	Physical Connection Active

Notation Conventions

-: Remain in current state
/: Cannot occur or discard
Gi: Go to state Gi
Ii: Send info i
AI: Generate PH AI Primitive
DI: Generate PH.DI Primitive
.: State Timer

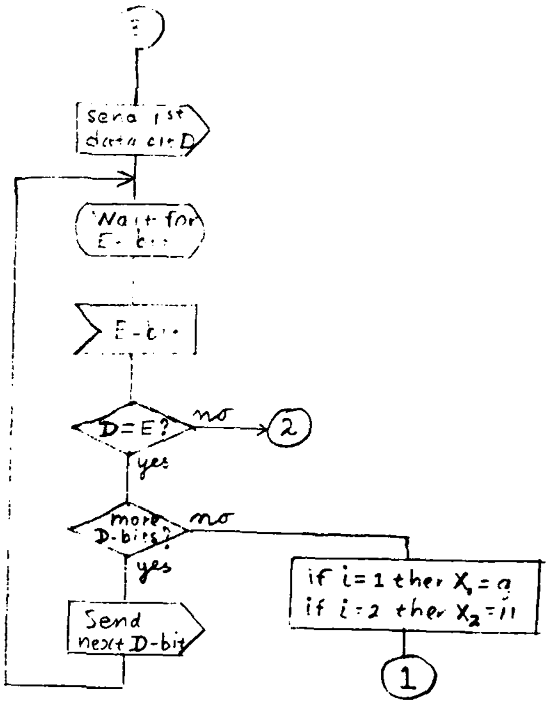
~~APPENDIX B~~



Legend: see part 3

SDL representation of a possible implementation of the D channel access

ANNEX I 431



Legend: D : D-channel bit
E : D-echo-channel bit
F : Flag indicating that frame is pending
C : number of consecutive ones detected on the D-echo channel
X_1 : threshold for priority class 1
X_2 : threshold for priority class 2
i : priority class indicator

: SDL representation of a possible
implementation [illegible] access

CCITT
STUDY GROUP XVIII,

Temporary Document 29-E

Geneva, 21 November -2 December 1983

Question : 1/XVIII

SOURCE : DRAFTING GROUP

TITLE : REPORT OF THE AD HOC GROUP ON RECOMMENDATION I.432

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1. General

An ad hoc Group under the chairmanship of Mr. F. E. Weber (United States, ATT) met to consider proposed changes to the draft Recommendation I.432 which specifies layer 1 of the primary rate user/network interface.

The terms of reference set out by the Chairman of Working Team 2 were:

- to review proposed modifications to Recommendation I.432;
- to produce a revised draft text.

2. Documents

The following documents in addition to COM XVIII-R18 were considered:

SS (Federal Republic of Germany), TM (NTT) and TW (ATT).

3. Discussion of draft Recommendation I.432

As suggested in Contributions SS (Federal Republic of Germany) and TW (ATT), it was agreed to replace the sections of Recommendation I.432 specifying electrical characteristics by references to the relevant sections of Recommendation G.703. This will minimize the possibility that unintentional differences are introduced into Recommendation I.432. References to other Recommendations (e.g. G.733) have been made as appropriate.

The revised draft text includes proposed time slot assignments for H_0-channels. These assignments are as proposed in Contributions SS (Federal Republic of Germany) for 2048 kbit/s and TM (NTT) for 1544 kbps. The time slot assignments cover the cases where either B- or H_0-channels (but not both) are present simultaneously on the interface.

For the case where B and H_0 are mixed, two possible arrangements have been identified. The first utilizes a fixed allocation for H_0-channels using consecutive time slots and permits unused time slots to be used for B-channels. The second permits a completely flexible assignment of time slots to form B- and H_0-channels. Both of these approaches are for further study.

During the discussion on functional requirements it was pointed out that the definition of some terms (e.g. B-channel, octet timing) are in some cases unclear. Since these definitions are common to several texts (e.g. I.431, I.432), it is suggested that they be reviewed by the Vocabulary Group to be made more precise.

Draft Recommendation I.432

PRIMARY RATE USER/NETWORK INTERFACE - LAYER 1 SPECIFICATION

1. Introduction

This Recommendation is concerned with the layer 1 electrical, format and channel usage characteristics of the primary rate user/network interface at the S and T reference points. Interfaces for the 1544 kbps primary rate and for the 2048 kbps primary rate are described. As an ultimate objective, the same primary rate user/network interface should be operable at 1544 kbps and 2048 kbps with the same TE/NT2 equipment. Any differences between the interface specifications for the two rates should be kept to a minimum.

This Recommendation is based on CCITT Recommendations G.703, G.732, G.733 and G.734.

In the future, alternate interface arrangements suitable for new technologies (e.g. fibre optics), different applications (e.g. longer transmitter-receiver distance), etc., may be specified.

1.1 Scope and field of application

This specification is applicable to user/network interfaces at 1544 kbit/s and 2048 kbit/s primary rates for ISDN channel arrangements as defined in draft Recommendation I.412.

2. Type of configuration

The type of configuration applies only to the layer 1 characteristics of the interface and does not imply any constraints on modes of operation at higher layers.

2.1 Point-to-point

The primary rate access will support only the point-to-point configuration.

Point-to-point configuration at layer 1 implies that only one source (transmitter) and one sink (receiver) are connected to the interface. The maximum reach of the interface in the point-to-point configuration is limited by the specification for the electrical characteristics of transmitted and received pulses and the type of interconnecting cable. These characteristics are as defined in Recommendation G.703.

3. Functional characteristics

3.1 Summary of functions

B-channel

This function provides for the bi-directional transmission of independent B-channel signals each having a bit rate of 64 kbit/s as defined in Recommendation I.412.

H_0-channels

This function provides for the bi-directional transmission of independent H_0-channel signals each having a bit rate of 384 kbit/s as defined in Recommendation I.412.

H_1-channel

This function provides for the bi-directional transmission of an H_1-channel signal having a bit rate of 1536 or 1920 kbit/s as defined in Recommendation I.412. (NOT YET IN I.412 – DEC. 1983.)

D-channel or E-channel

This function provides for the bi-directional transmission of one D-channel signal or one E-channel signal at a bit rate of 64 kbit/s as defined in Recommendation I.412.

Bit timing

This function provides bit (signal element) timing to enable the terminal or NT to recover information from the aggregate bit stream.

Octet timing

This function provides 8 kHz timing towards the terminal or NT for the purpose of enabling an octet structure for PCM voice coders and for other timing purposes as required.

Frame alignment

This function provides information to enable the terminal or NT to recover the time-division multiplexed channels.

Maintenance

The definition and use of these functions are for further study.

3.2 Interchange circuits

Two interchange circuits, one for each direction, are used for the transmission of digital signals. All the functions above-listed, with the possible exception of maintenance, are combined into two composite digital signals, one for each direction of transmission.

4. Interface at 1544 kbit/s

4.1 Electrical characteristics

This interface should conform to Recommendation R.703, section 2, which recommends the basic electrical characteristics of this interface, such as bit rate, pulse shape, impedance, and code. The B8ZS format is recommended for ISDN use.

Note - It is recognized that revisions to Recommendation G.703 are expected as a result of studies under Q.15/XVIII (see COM XVIII-R 13, section II.4.1, which describes B8ZS) and it is intended that the reference given here will be to the revised version as finally adopted. (This Not is to be removed in final drafting.)

Note - A CMI (Coded Mark Inversion) code was proposed as an alternative to the B8ZS code for the ISDN 1544 kbit/s user/network interface. Selection of a line code for future application should be made after extensive studies and comparison between these two codes have been carried out taking into account future possible media such as optical fibre and radio.

4.2 Frame structure

4.2.1 24-frame multiframe

4.2.1.1 The frame structure is based on Recommendation G.733 and is shown in Figure 1/I.432.

4.2.1.2 Each frame is 193 bits long and consists of an F-bit followed by 24 consecutive time slots, numbered 1 to 24.

4.2.1.3 Each time slot consists of 8 consecutive bits, numbered 1 to 8.

4.2.1.4 The frame repetition rate is 8,000 frames/sec.

4.2.1.5 The multiframe structure is shown in Table 1/I.432. Each multiframe is 24 frames long and is defined by the multiframe alognment signal (FAS) formed by every fourth F-bit.

4.2.1.6 The bits e_1 to e_6 in Table 1/I.432 are used for error checking in G.733, section 2.1.5. Their use in this recommendation is for further study. The use of the M bits is for further study.

4.3 Time slot assignment

4.3.1 D- or E-channel

Time slot 24 is assigned to the D-channel or E-channel when either of these channels is present.

4.3.2 B-channel

One time slot from the set of time slots 1 to 23 may be assigned to form each B-channel. If neither the D-channel nor the E-channel is present, time slot 24 may be assigned to a B-channel.

4.3.3 H_0-channel

Six time slots, 1 to 6, 7 to 12 or 13 to 18 are assigned to form each H_0-channel. The six time slots 19 to 24 are assigned to form an H_0-channel if neither the D-channel nor the E-channel is present.

4.3.4 B- and H_0-channels

When B- and H_0-channels are present simultaneously on the same primary rate interface, two approaches are identified. The first utilizes assignment of H_0-channels as in section 4.3.3, and permits allocation of unused time slots for B-channels. The second permits a completely flexible assignment of time slots to form B- and H_0-channels. Both approaches are for further study.

4.3.5 H_1-channel

For an H_1-channel bit rate of 1536 kbit/s, time slots 1 through 24 are assigned to one H_1-channel.

4.3.6 Other channels

For further study.

4.4 Timing considerations

This section describes the hierarchical synchronization method selected for synchronizing ISDNs. It is based upon consideration of satisfactory customer services, ease of maintenance, administration and minimizing cost.

4.4.1 The NT derives its timing from the network clock. The TE synchronizes its timing (bit, octet, framing) from the signal received from the NT and synchronizes accordingly its transmitted signal.

4.4.2 Timing signals provide a co-directional interface.

4.5 Interface procedures

4.5.1 Idle channel code (for further study)

4.5.2 Maintenance (for further study)

4.5.3.1 Out of frame detection

A reframe procedure must start when the fraction of the framing bits in error is in the range from 2 out of 5 to 2 out of 4.

4.5.3.2 False framing

The framing strategy must be such that channel framing should not falsely lock on the signalling framing.

4.5.3.3 Reframe duration

Maximum average reframe time shall be less than 40 milliseconds in the absence of errors (maximum average reframe time is the average time to reframe when the maximum number of bit positions must be examined for the framing pattern).

Note - This section (~~4.4.3~~ 4.5.3) specifies terminal equipment, not the interface. Hence, consideration should be given to locating it elsewhere. (This Note is to be removed in final drafting.)

5. Interface at 2048 kbit/s

5.1 Electrical characteristics

This interface should conform to Recommendation G.703, section 6, which recommends the basic electrical characteristics.

5.2 Frame structure

5.2.1 Number of bits per time slot

Eight, numbered from 1 to 8.

5.2.2 Number of time slots per frame

Thirty-two, numbered from 0 to 31. The number of bits per frame is 256, and the frame repetition rate is 8 000 Hz.

5.2.3 Frame alignment signal

The frame alignment signal occupies positions 2 to 8 in channel time slot 0 of every other frame (see Table 2/I.432).

The frame alignment signal is : 0011011.

In order to avoid simulation of the frame alignment signal by bits 2 to 8 of channel time slot 0 in frames not containing the frame alignment signal, bit 2 in those channel time slots is fixed at 1.

5.2.4 Time slot assignment

5.2.4.1 Frame alignment signal

Time slot 0 is assigned to frame alignment in accordance with paragraph 5.2.3.

5.2.4.2 D- or E-channel

Time slot 16 is assigned to the D-channel or E-channel when either of these channels is present. The assignment of time slot 16 when not used for a D- or E-channel is for further study.

5.2.4.3 B-channel

Time slots 1 to 15 and 17 to 31 are assigned to 30 B-channels numbered from 1 to 30.

5.2.4.4 H_0-channel

The time slot assignment for the H_0-channel is shown in Table 3/I.432.

5.2.4.5 B- and H_0-channels

When B- and H_0-channels are present simultaneously on the same primary rate interface, two approaches are identified.

The first utilizes assignment of H_0-channels as in 5.2.4.4 and permits allocation of unused time slots for B-channels.

The second permits a completely flexible assignment of time slots to form B- and H_0-channels. Both approaches are for further study.

5.2.4.6 H_1-channel

Time slots 1 to 15 and 17 to 31 are assigned to one H_1-channel at 1920 kbit/s.

5.2.4.7 Other channels (for further study)

5.3 Timing considerations

This section describes the hierarchical synchronization method selectedfor synchronizing ISDNs. It is based upon consideration of statisfactory customer service, ease of maintenance, administration and minimizing cost.

5.3.1 The NT derives its timing from the network clock. The TE synchronizes its timing (bit, octet, framing) from the signal received from the NT and synchronizes accordingly its transmitted signal.

5.4 Interface procedures

5.4.1 Idle channel code (for further study)

5.4.2 Maintenance (for further study)

5.4.3 Frame alignment procedures

Frame alignment will be assumed to have been lost when three or four consecutive frame alignment signals have been received with an error.

Frame alignment will be assumed to have been recovered when the following sequence is detected :

for the first time, the presence of the correct frame alignment signal;

the absence of the frame alignment signal in the following frame detected by verifying that bit 2 in channel time slot 0 is a 1;

for the second time, the presence of the correct frame alignment signal in the next frame.

<u>Note 1</u> - To avoid the possibility of a state in which no frame alignment can be achieved due to the presence of an imitative frame alignment signal the following procedure may be used :

When a valid frame alignment signal is detected in frame n, a check should be made to ensure that a frame alignment signal does not exist in frame n + 1, and also that a frame alignment signal exists in frame n + 2. Failure to meet one or both of these requirements should cause a new search to be initiated in frame n + 2.

<u>Note 2</u> - It is intended that this frame alignment procedure will be revised to be in accordance with relevant amendments adopted under Q.18/XVIII.

6. <u>Mechanical</u>

To be specified.

6.1 <u>Connector</u>

For further study.

Connection to the primary rate interface should be made via a suitable connector. The following are preliminary requirements to facilitate selection of a connector.

The connector should be :

- rugged;
- positive latching;
- self-orienting;
- common to all primary rate applications;
- suitable for use at speeds of 1544/2048 kbit/s.

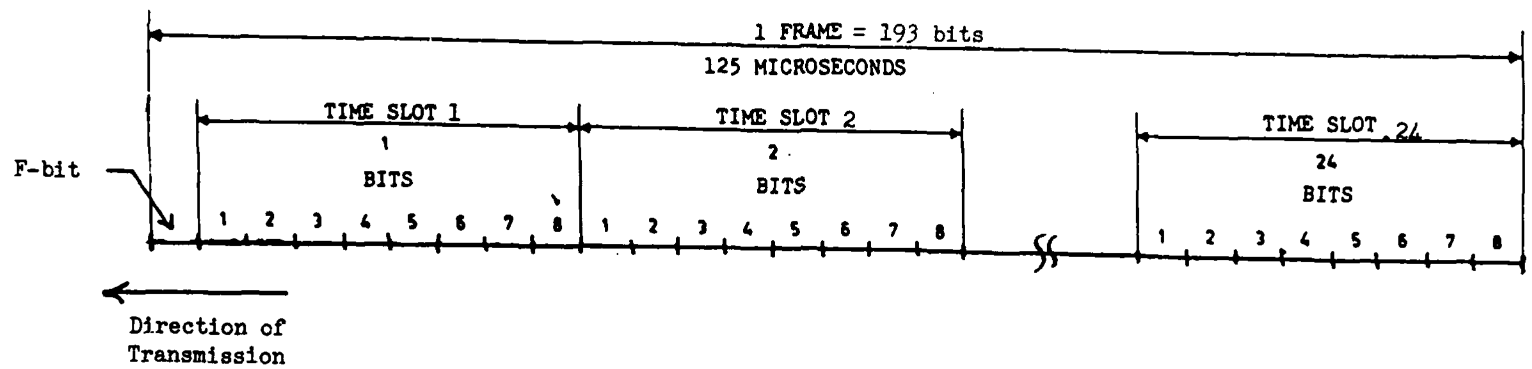

FIGURE 1/I.432

Frame structure of 1544 kbps interface

TABLE 1/I.432

Multi-frame Frame Number	F-Bits			
	Multi-frame bit number	Assignments		
		FAS	R	CRC
1	0	-	m	-
2	193	-	-	e_1
3	386	-	m	-
4	579	0	-	-
5	772	-	m	-
6	965	-	-	e_2
7	1158	-	m	-
8	1351	0	-	-
9	1544	-	m	-
10	1737	-	-	e_3
11	1930	-	m	-
12	2123	1	-	-
13	2316	-	m	-
14	2509	-	-	e_4
15	2702	-	m	-
16	2895	0	-	-
17	3088	-	m	-
18	3281	-	-	e_5
19	3474	-	m	-
20	3667	1	-	-
21	3860	-	m	-
22	4053	-	-	e_6
23	4246	-	m	-
24	4439	1	-	-

FAS : Frame Alignment Signal (...001011...)

CRC : CRC-6 Block Check Field (check bits e_1 - e_6)

R : The use of the m-bits is for further study.

TABLE 2/I.432

Allocation of bits in channel time slot 0

	Bit number							
	1	2	3	4	5	6	7	8
Time slot 0 containing the frame alignment signal	(see Note 1)	0 Frame alignment signal (see § 5.2.3)	0	1	1	0	1	1
Time slot 0 not containing the frame alignment signal	(see Note 1)	1 (see § 5.2.3)	(see Note 1)	(see Note 1)				

Note 1 – The use will be defined at a later stage

TABLE 3/I.432

Time slot assignment for H_0-channels

	H_0 channels: A	B	C	D	E
time slots	1 - 2 - 3 17 - 18 - 19	4 - 5 - 6 20 - 21 - 22	7 - 8 - 9 23 - 24 - 25	10 - 11 - 12 26 - 27 - 28	13 - 14 - 15 29 - 30 - 31

[Note: Time slot 16 is thus available for ISDN signalling (D or E channel — NOT D or E channel in tab 6).]

International Telegraph and Telephone
Consultative Committee
(CCITT)

Period 1981-1984

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Recommendation Q.920 (I.441) - Issue 6

SPECIFICATION OF THE ISDN USER-NETWORK INTERFACE

DATA LINK LAYER PROTOCOL

CONTENTS

1 General

1.1 Scope and field of application

This Recommendation defines the frame structure, elements of procedure and procedures for the proper operation of the Link Access Procedure on the D-channel, LAPD. The application of this protocol to other channel types is for further study.

The purpose of LAPD is to convey information between layer 3 entities across the ISDN user-network interface using the D-channel.

The definition of LAPD uses the principles and terminology of :

- CCITT Recommendation X.200 [1] and X.210 [2] - the reference model for Open Systems Interconnection (OSI);
- CCITT Recommendation X.25 [3] LAPB - user-network interface for packet mode terminals;
- ISO 3309 [4] and ISO 4335 [5]- high-level data link control (HDLC) standards for frame structure and elements of procedures.

LAPD is a protocol that operates at the data link layer of the OSI architecture. The relationship between the data link layer and other protocol layers is defined in Recommendation I.311 [6].

Note 1 - The physical layer is defined in Recommendation I.431 [7]and I.432 [8]and the layer 3 is defined in Recommendation Q.930 (I.451) [9]. Reference should be made to these Recommendations for the complete definition of the protocols and procedures across the ISDN user-network interface.

Note 2 - The term "data link layer" is used in the main text of this Recommendation. However, mainly in figures and tables, the terms "layer 2" and "L2" are used as abbreviations. Furthermore, in accordance with Recommendations Q.929 (I.450) [10] and Q.930 (I.451) [9], and term "layer 3" is used to indicate the layer above the data link layer.

LAPD is independent of transmission bit rate. It requires a full duplex, bit transparent D-channel.

The characteristics of the D-channel are defined in Recommendation I.412.

Section 1.2 below describes basic concepts used in this Recommendation.

Section 1.3 gives an overview description of LAPD functions and procedures.

Section 1.4 summarizes the services that the data link layer provides to layer 3 and the services that the data link layer requires from the physical layer.

Section 1.5 provides an overview over the data link layer structure.

1.2 Concepts and terminology

The basic structuring technique in the OSI model is layering. According to this technique, communication among application processes is viewed as being logically partitioned into an ordered set of layers represented in a vertical sequence as shown in Figure 1-1/Q.920.

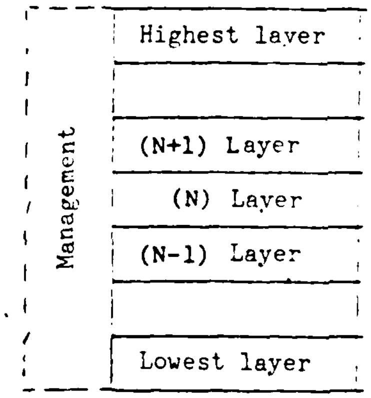


FIGURE 1-1/Q.920

Layering

Entities exist in each layer. Entities in the same layer but in different systems which must exchange information to achieve a common objective are called "peer entities". Entities in adjacent layers interact through their common boundary. The services provided by the data link layer are the results of the services and functions provided by both the data link layer and the physical layer.

A data link layer service access point (SAP) is the means by which the data link layer provides services to the layer 3. Associated with each data link layer SAP are one or more data link connection endpoint(s). See Figure 1-2/Q.920. A data link connection endpoint is identified by a data link connection endpoint identifier as seen from the network layer and by a data link connection identifier (DLCI) as seen from the data link layer.

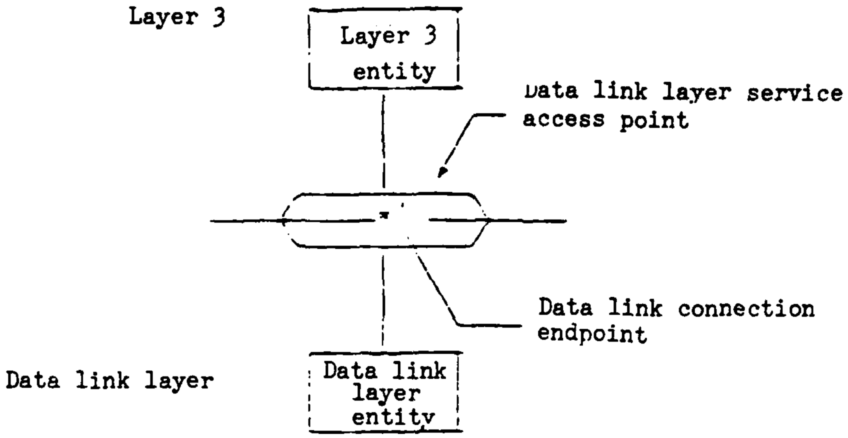


FIGURE 1-2/Q.920

Entities, service access points and endpoints

Cooperation between data link layer entities is governed by a peer-to-peer protocol specific to the layer. In order for information to be exchanged between two or more network entities, an association must be established in the data link layer. This association is called a data link connection. Data link connections are provided by the data link layer between two or more SAPs (see Figure 1-3/Q.920).

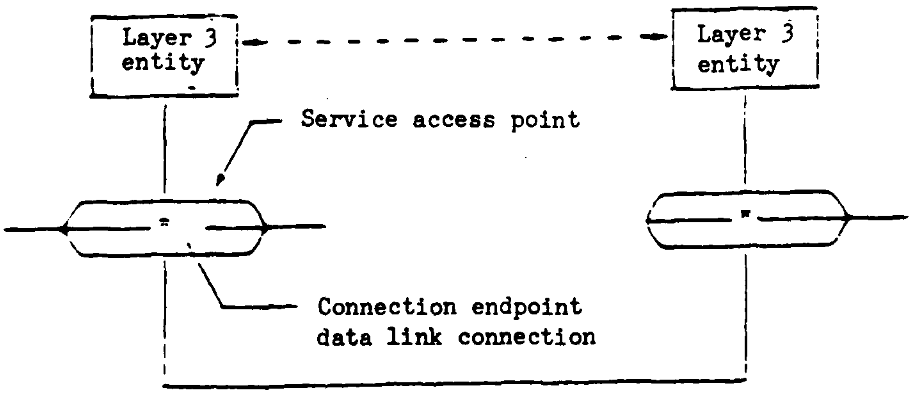


FIGURE 1-3/Q.920

Peer-to-peer relationship

Data link layer message units are conveyed between data link layer entities by means of a physical connection.

The network layer requests services from the data link layer via service primitives. The same applies for the interaction between the data link layer and the physical layer. The primitives represent, in an abstract way, the logical exchange of information and control between the data link layer and adjacent layers. They do not specify or constrain the implementation of entities or interfaces.

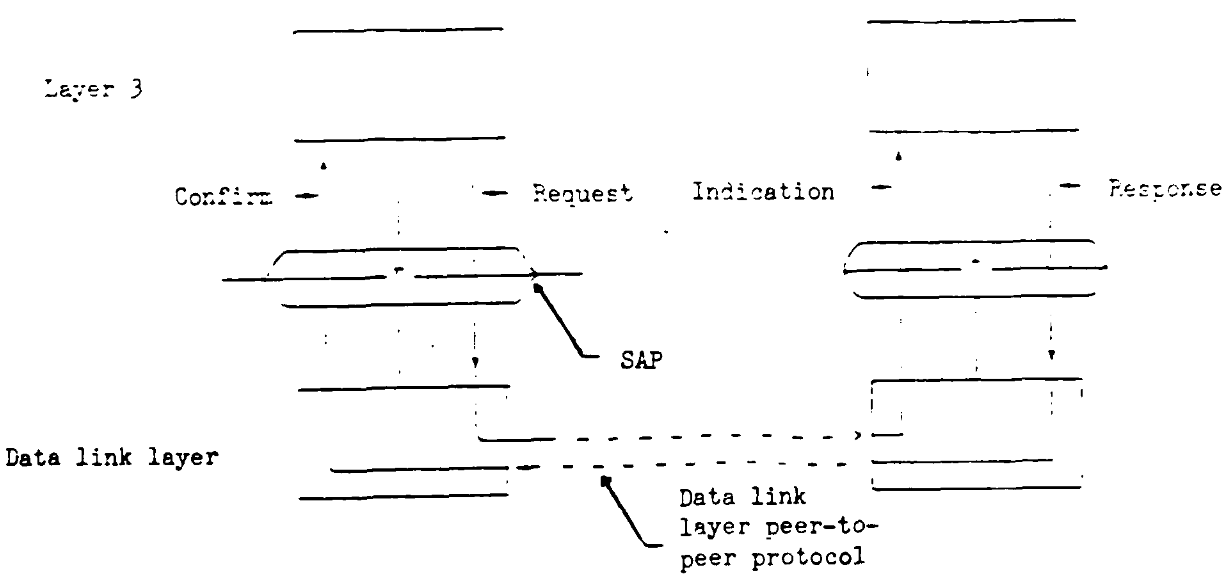
The primitives that are exchanged between the data link layer and adjacent layers are of the following four types (see also Figure 1-4/Q.920) :

a) request;

b) indication;

c) response;

d) confirm.



Note - The same principle applies for data link layer - physical layer interactions.

FIGURE 1-4/Q.920

Primitive action sequence

The REQUEST primitive type is used when a higher layer is requesting a service from the next lower layer.

The INDICATION primitive type is used by a layer providing a service to notify the next higher layer of activities related to the primitive type request.

The RESPONSE primitive type is used by a layer to acknowledge receipt, from a lower layer, of the primitive type INDICATION.

The CONFIRM primitive type is used by the layer providing the requested service to confirm that the activity has been completed.

Layer-to-layer interactions are specified in Section 4.

Information is transferred, in various types of message units, between peer entities and between entities in adjacent layers that are attached to a specific SAP. The message units are of two types:

- Message units of a peer-to-peer protocol.

- Message units that contain layer-to-layer information concerning status and specialized service requests.

The message units of the layer 3 peer-to-peer protocol are carried by the link connection. The message units containing layer-to-layer information concerning status and specialized service requests are never conveyed over a link or a physical connection.

This Recommendation specifies (see also Figure 1-5/Q.920) :

a) The peer-to-peer protocol for the transfer of information and control between any pair of data link layer service access points.

b) The interactions between the Data Link Layer and the Network Layer, and between the data link layer and the physical layer.

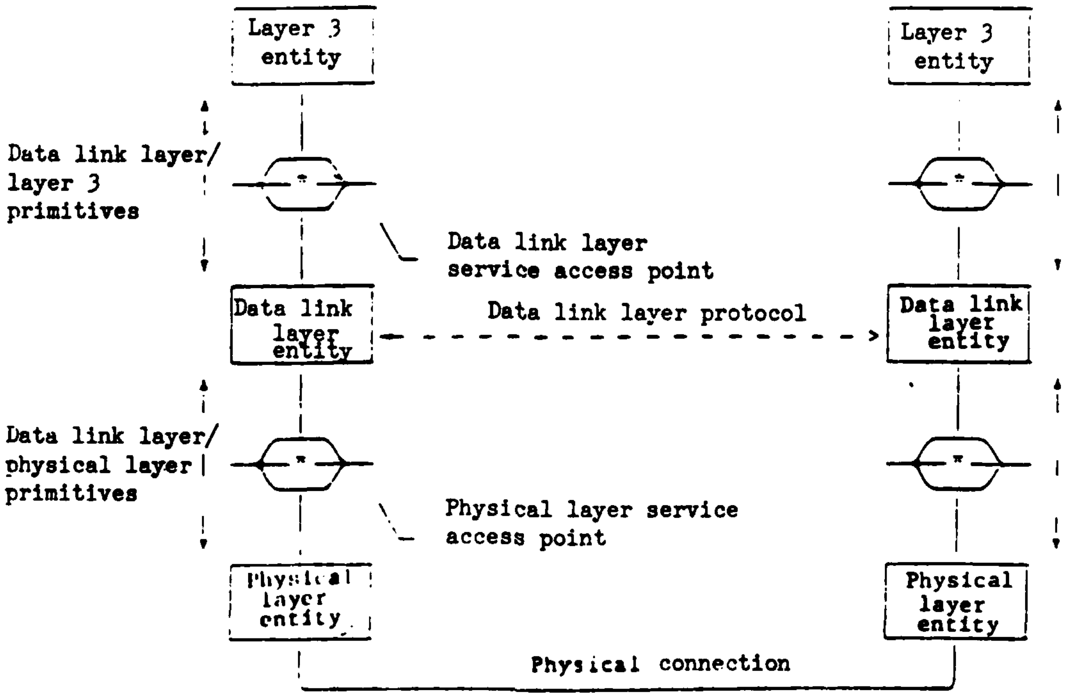


FIGURE 1-5/Q.920

Data link layer reference model

1.3 Overview description of LAPD functions and procedures

1.3.1 General

The purpose of LAPD is to convey information between layer 3 entities across the ISDN user-network interface using the D-channel. Specifically, LAPD will support :

- multiple terminal installations at the user-network interface;
- multiple layer 3 entities.

All data link layer messages are transmitted in frames which are delimited by flags. (A flag is a unique bit pattern.) (The frame structure is defined in Section 2).

LAPD includes functions for:

a) The provision of one or more data link connections on a D-channel. Discrimination between the data link connections is by means of a data link connection identifier (DLCI) contained in each frame;

b) frame delimiting, alignment and transparency, allowing recognition of a sequence of bits transmitted over a D-channel as a frame;

c) sequence control, to maintain the sequential order of frames across a data link connection;

d) detection of transmission, format and operational errors on a data link;

e) recovery from detected transmission, format and operational errors and notification to layer 3 of unrecoverable errors;

f) flow control.

Data link layer functions provide the means for information exchange between multiple combinations of link endpoints. The information transfer may be via point-to-point links or via broadcast links. In the case of point-to-point information transfer, a frame is directed to a single endpoint while in the case of broadcast information transfer a frame is directed towards one or more endpoints.

Figure 1-6/Q.920 shows two examples of point-to-point information transfer and Figure 1-7/Q.920 shows an example of broadcast information transfer.

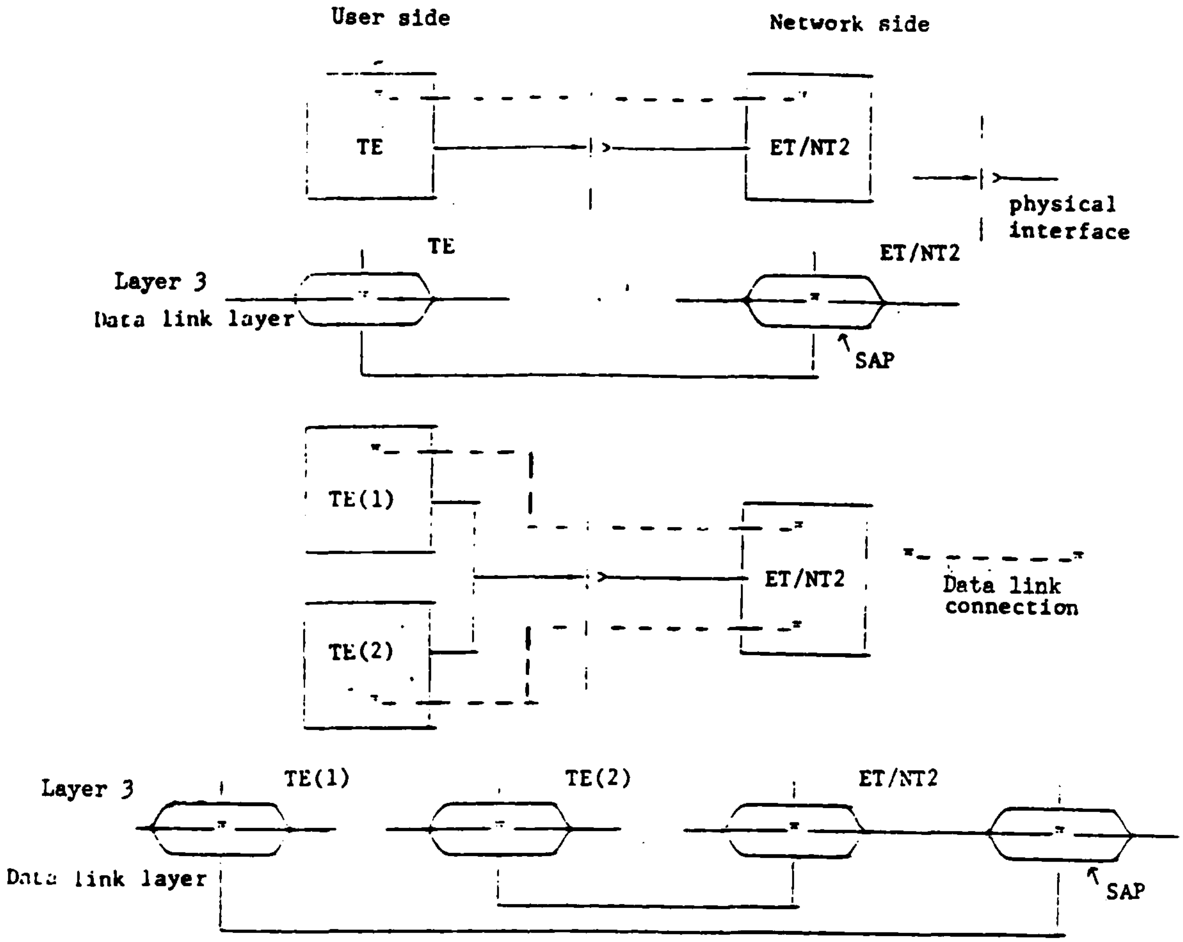


FIGURE 1-6/Q.920

Point-to-point links

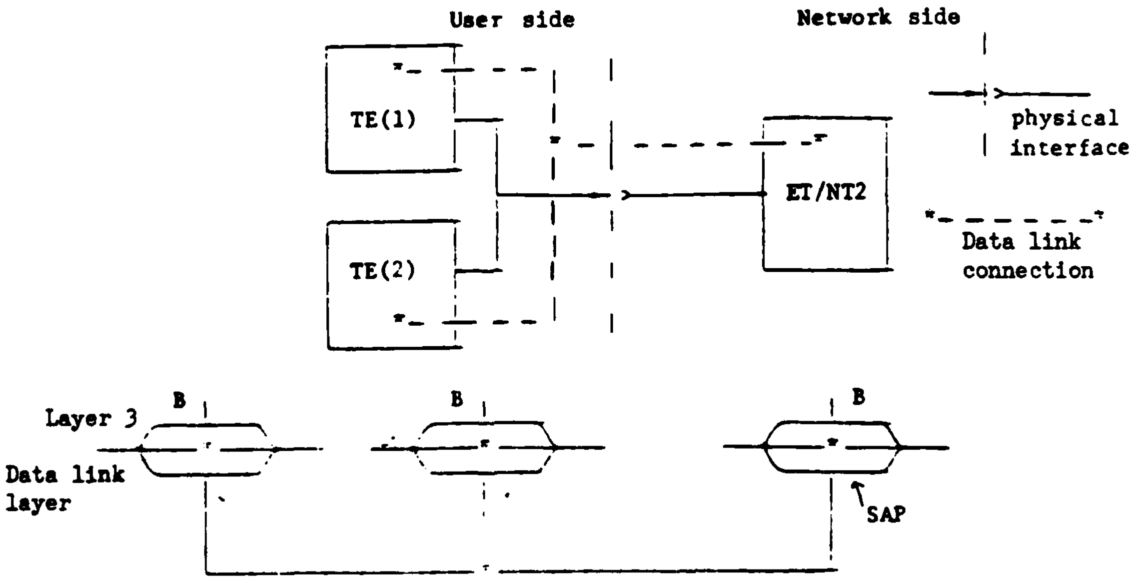


FIGURE 1-7/Q.920

Two types of operation of the data link layer are defined for layer 3 information transfer : unacknowledged, and acknowledged. They may coexist on a single D-channel.

1.3.2 Unacknowledged operation

With this type of operation layer 3 information is transmitted in unnumbered information (UI) frames.

At the data link layer the UI frames are not acknowledged. Transmission and format errors may be detected but no error recovery mechanism is defined. Flow control mechanisms are not defined.

Unacknowledged operation is applicable for point-to-point and broadcast information transfer; e.g. an information frame may be sent to a specific endpoint or be broadcast to multiple endpoints associated with a specific service-access-point indentifier (SAPI).

1.3.3 Acknowledged operation

With this type of operation, layer 3 information is sent in frames that are acknowledged at the data link layer.

Error recovery procedures based on retransmission of unacknowledged frames are specified. In the case of errors which cannot be corrected by the data link layer, a report to the layer 3 is made. Flow control procedures are also defined.

Acknowledged operation is applicable for point-to-point information transfer.

Two forms of acknowledged information transfer are defined.

a) single frame operation;

b) multiple frame operation.

In the case of single frame operation, layer 3 information is sent in "To Be Named" (TBN)[1] frames, using the P/F bit as a modulo sequence number. No frame is sent until an aknowledgement has been received for a previously sent frame; i.e., only one frame may be outstanding at the same time.

In the case of multiple frame operation, layer 3 information is sent in numbered information (I) frames. A number of I frames may be outstanding at the same time. Multiple frame operation is initiated by a multiple frame establishment procedure using Set Asynchronous Balanced Mode/Set Asynchronous Balanced Mode Extended (SABM/SABME) commands. See section 5.6.1.

Note 1 - The provision of extended multiple frame operation (modulo 128 sequence numbering) is provisional and may not be supported by every network.

Note 2 - Urgent further study is needed on the acknowledged single frame operation and its need beyond an interim period.

---

1 The name to be determined later.

1.3.4 Establishment of information transfer modes

1.3.4.1 Data link connection identification

A data link connection is identified by a data link connection identifier carried in the address field of each frame.

The data link connection identifier is associated with a connection endpoint identifier at the two ends of the link (see Figure 1-8/Q.920). The connection endpoint identifier is used to identify message units passed between the data link layer and layer 3. The data link connection identifier consists of two elements : the service access point identifier (SAPI) and the terminal endpoint identifier (TEI).

The SAPI is used to identify the service access point in the network or the user.

The TEI is used to identify a specific connection endpoint within a service access point.

The TEI may be assigned automatically by means of a separate TEI assignment procedure (see section 1.3.4.3) or it may be assigned at the time of subscription and may be entered into the user equipment; e.g., by the subscriber of the manufacturer.

In the latter case, the TEI value must be verified to ensure that the TEI is not already used by another user equipment. This verification is performed making use of the same procedure used for TEI assignment.

1.3.4.2 Link states

A point-to-point data link may be in one of four basic states, see Figure 1-9/Q.920. :

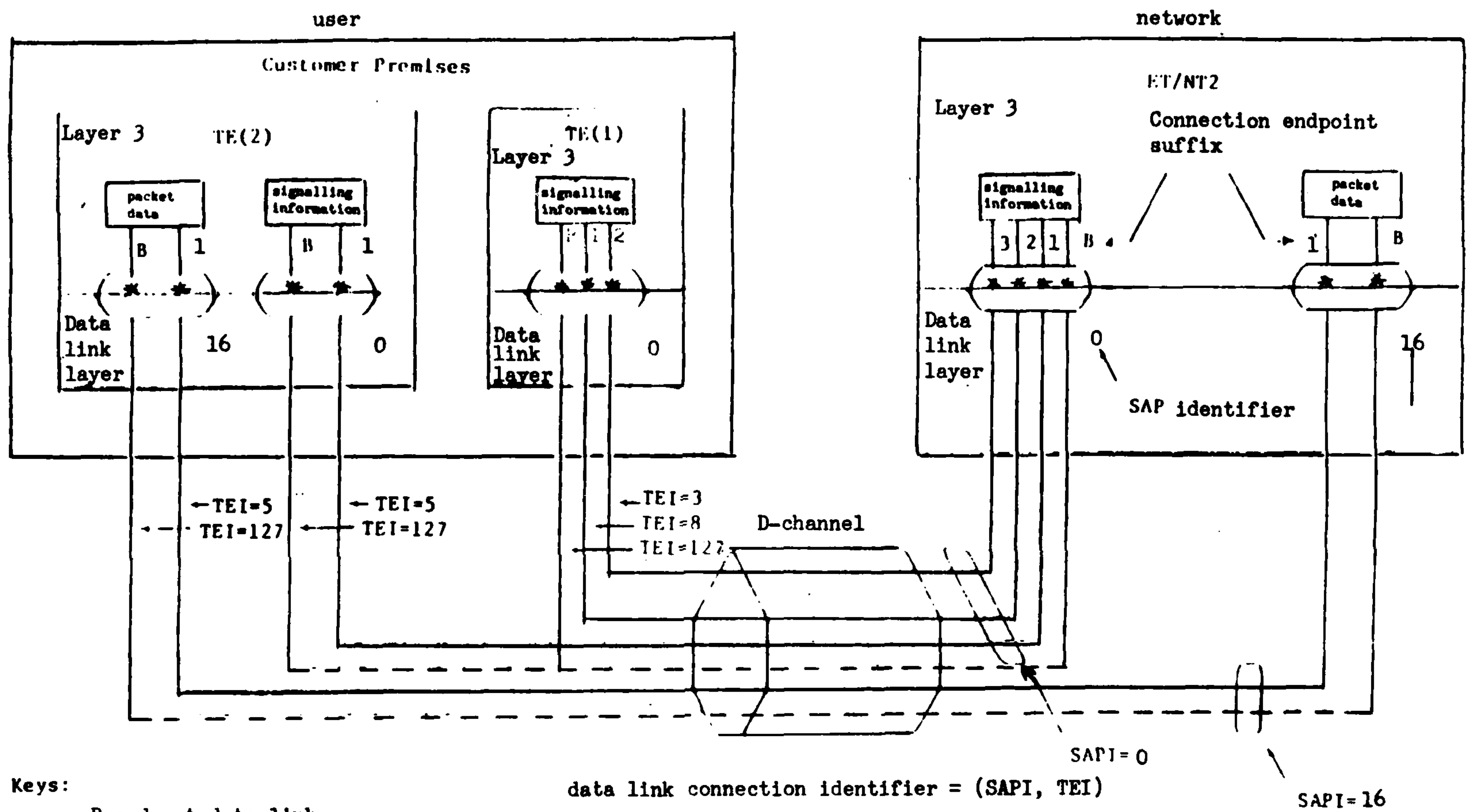
i) TEI unassigned state. In this state a TEI has not been assigned or verified. No information transfer is possible.

ii) TEI assigned state. In this state a TEI has been assigned/verified by means of the TEI assignment procedure. Unacknowledged information transfer is possible.

iii) Single-frame-established-state. Acknowledged single frame and unacknowledged information transfer is possible.

iv) Multiple-frame-established-state. This state is established by means of a multiple frame establishment procedure. Acknowledged multiple frame and unacknowledged information transfer is possible.

A broadcast link is always in an information transfer state capable of unacknowledged information transfer.



Keys:
------ Broadcast data link
______ Point-to-point data link

Connection endpoint identifier =
SAP identifier + connection endpoint suffix

Note - The management entity is not shown in this Figure.

FIGURE 1-8/Q.920

Overview description of the relation between SAPI, TEI and data link connection endpoint identifier

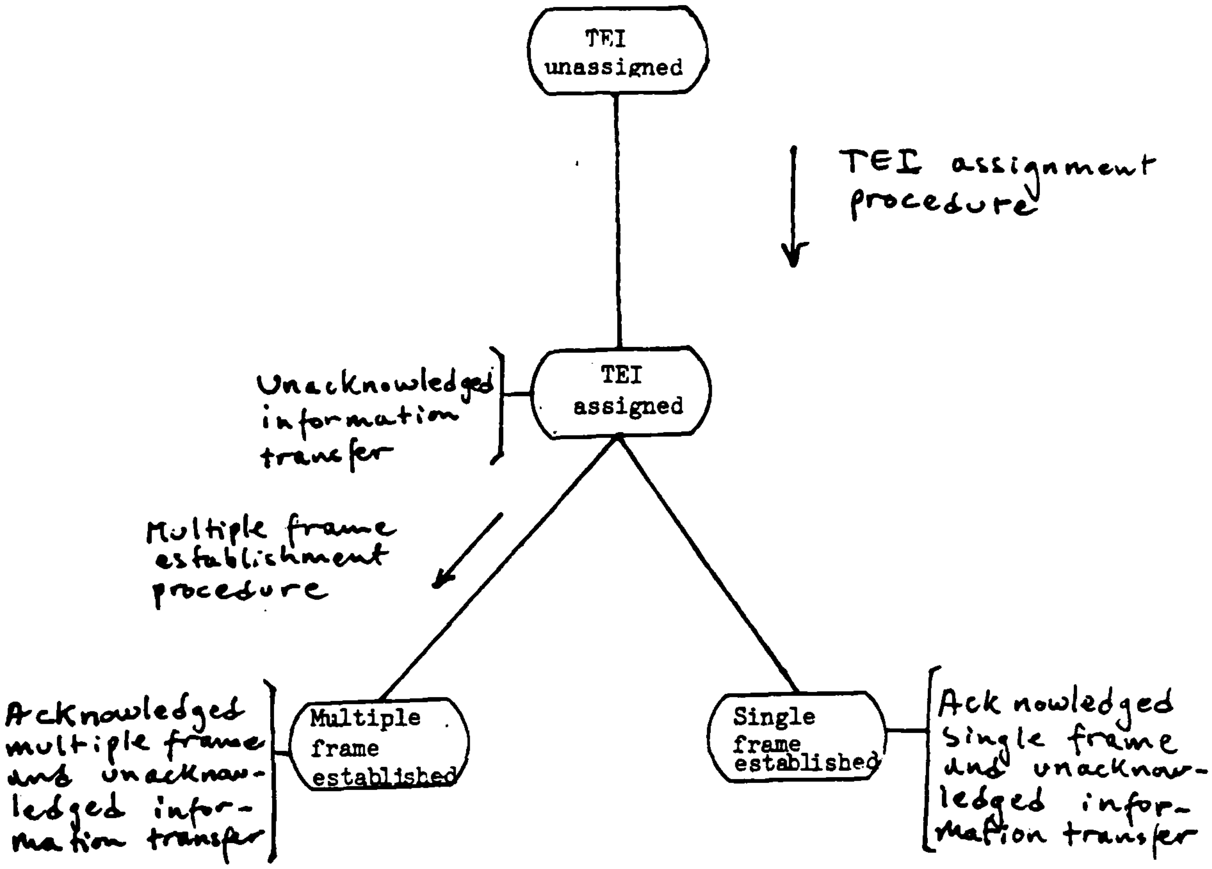


FIGURE 1-9/Q.920

Basic link states for point-to-point link

1.3.4.3 Automatic TEI assignment procedure

The purpose of this procedure is to :

a) allow a user equipment to request the network to send a TEI value that data link layer entities within the requesting user equipment will use in subsequent communications over the data link;

b) allow a user equipment to request the network to verify a TEI value, already present in the user equipment, that data link entities within the requesting user equipment will use in subsequent communications over the data link.

The assigned TEI value is typically common to all SAPs (if more than one) in a user equipment. The procedure is conceptually located in the management entity.

When a TEI has been assigned/verified, the user establishes an association between the TEI and a connection endpoint suffix of each SAP; i.e., data link connection identifier is associated with connection endpoint identifier. In the network, the corresponding association is made upon reception of the first frame containing the assigned/verified TEI.

At that point in time, a point-to-point data link layer connection exists.

The association between the data link connection identifier and connection endpoint identifier will be removed :

a) in the network, on request from layer 3, or by the data link layer itself;

b) in the user on request from the management entity; e.g., when recognizing that the TEI value is no longer valid, or by the data link layer itself.

When in the TEI-assigned state, the TEI assignment procedure may be used to check the status of a TEI; e.g., to determine if a user equipment has been disconnected from an installation.

Examples of criteria for initiation of the TEI assignment procedure and for the removal of TEI values are described in section 5.3, together with the detailed specification of the TEI assignment procedure.

Note - This section is not intended to provide a complete specification of possible criteria for establishing and removing an association between data link connection identifier and connection endpoint identifier.

1.3.4.4 Establishment of single frame operation

The signle frame operation is established upon request from the local layer 3 of upon receipt of a "To Be Named" frame. No explicit peer-to-peer procedure is defined for this purpose.

1.3.4.5 Establishment of multiple frame operation

Before point-to-point multiple frame information transfer may start an exchange of SABM/SABME and Unnumbered Acknowledgement (UA) frames takes place.

The multiple frame establishment procedure is specified in detail in section 5.6.

1.4 Service characteristics

1.4.1 General

The data link layer provides services to layer 3 and utilizes the services provided by the physical layer.

Note - Communication between different entities in the OSI layered model makes use of primitives to be passed accross interfaces. Primitives represent, in an abstract way, the logical exchange of information and control between the data link and adjacent layers. They do not specify or constrain the implementation of entities or interfaces.

1.4.2 Services provided to layer 3

The specification of the interactions with layer 3 (primitives) provides a description of the services that the data link layer plus the physical layer offer to layer 3, as viewed from layer 3.

Two forms of information transfer services are associated with layer 3. The first is based on unacknowledged information transfer at the data link layer while the second service is based on acknowledged information transfer at the data link layer.

The data link layer also provides administrative services to layer 3 in order to implement information transfer services. Layer 3 message units are handled according to their respective layer 3 priority.

1.4.2.1 Unacknowledged information transfer service

Note - In this case the information transfer is not acknowledged at the data link layer. Acknowledgement procedures may be provided at higher layers.

The information transfer is via broadcast or point-to-point links.

The characteristics of the unacknowledged information transfer service are summarized in the following:

a) provision of a data link connection between layer 3 entities for unacknowledged information transfer of layer 3 message units;

b) identification of data link connection endpoints to permit a network layer entity to identify another layer 3 entity;

c) no verification of message arrival within the data link layer.

The primitives associated with the unacknowledged information transfer service are:

DL-UNIT DATA-REQUEST/INDICATION

The DL-UNIT DATA-REQUEST primitive is used to request that a message unit be sent using the procedures for unacknowledged information transfer service; DL-UNIT DATA-INDICATION indicates the arrival of a message unit.

1.4.2.2 Acknowledged information transfer services

Two modes of operation are available: single frame and multiple frame:

The characteristics of these services are summarized in the following:

a) Provision of data link connection between network layer entities for acknowledged transfer of layer 3 message units.

b) Identification of data link connection endpoints to permit a network layer entity to identify another network layer entity.

In addition, the multiple frame operation offers the following services :

multiple frame operation offers the following services

c) Sequence integrity of data link layer message units.

d) Notification to the layer 3 of unrecoverable errors detected by the data link layer.

e) Flow control.

The primitives are :

a) Data transfer

DL-DATA-REQUEST/INDICATION

The DL-DATA-REQUEST primitive is used to request that a message unit be sent using the procedures for these services; DL-DATA-INDICATION indicates the arrival of a message unit. These primitives are used for both single frame and multiple frame operations

b) Establishment of single or multiple frame operation

DL-ESTABLISH-REQUEST/INDICATION

These primitives are used to request and indicate the establishment of either the single frame or the multiple frame operation between two service access points.

c) Termination of single or multiple frame operation

DL-RELEASE-REQUEST/INDICATION

These primitives are used to request and indicate an attempt to terminate single or multiple frame operation between two service access points.

1.4.2.3 Administrative services

The characteristics of the administrative services are summarized in the following:

a) assignment and removal of TEI-values to be used on all point-to-point data link connections;

b) data link connection parameter passing between the network and the user.

Note - The procedures for parameter passing are for further study.

Some of these services are considered to be conceptually provided via the management entity within the user or network. The method of describing these administrative functions uses service primitives.

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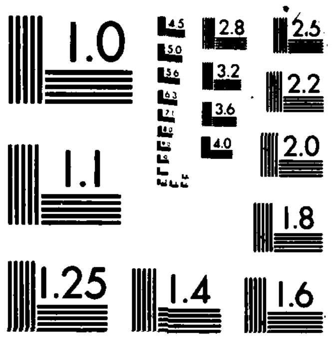

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Note - It is recognized that the current OSI layered model does not completely define the management entity and its relations with layer entities. The use of the term "service primitives" between management entity and data link layer entity is provisionally adopted in this Recommendation together with its representation method using "MDL". The appropriateness of the name and the representation method is for further study.

The primitives associated with these services are :

a) assignment of TEI-value

MDL-ASSIGN-REQUEST/INDICATION

These primitives are used to convey a TEI, obtained or verified via the automatic TEI assignment procedure in the management entity, from the management entity to the data link layer in order that the user data link layer entities can begin to communicate with the network data link layer entities using the assigned TEI value.

b) removal of TEI-value

MDL-REMOVE-REQUEST

These primitives are used to convey a management function request for removal of a TEI value that has been previously assigned via the MDL-ASSIGN primitives.

1.4.3 Services required from the physical layer

The services provided by the physical layer are described in detail in Recommendation I.431 [7] or I.432 [8]. They are summarized in the following :

a) physical layer connection for the transparent transmission of bits in the same order in which they are submitted to the physical layer;

b) indication of the physical status of the D-channel;

c) transmission of data link layer message units according to their respective data link layer priority;

Some of the above services may be implemented via the management entity within the user side or network side. Since the CCITT has not defined these functions, the method of describing these services is via service primitives. The primitives associated between data link layer and physical layer are:

a) Data transfer

PH-DATA-REQUEST/INDICATION

These primitives are used to request that a message unit be sent and to indicate the arrival of a message unit.

b) PH-ACTIVATE-INDICATION

This primitive is used to indicate that the physical layer has been activated.

c) PH-DEACTIVATE-INDICATION

This primitive is used to indicate that the physical layer has been deactivated.

1.5 Overview of data link layer structure

Figure 1-10/Q.920 is a functional block diagram of the data link layer supported on a single D-channel that could exist on the network.

The user configuration may be a subset of this figure.

Figure 1-10/Q.920 illustrates two procedural types : the link procedure and the multiplex procedure.

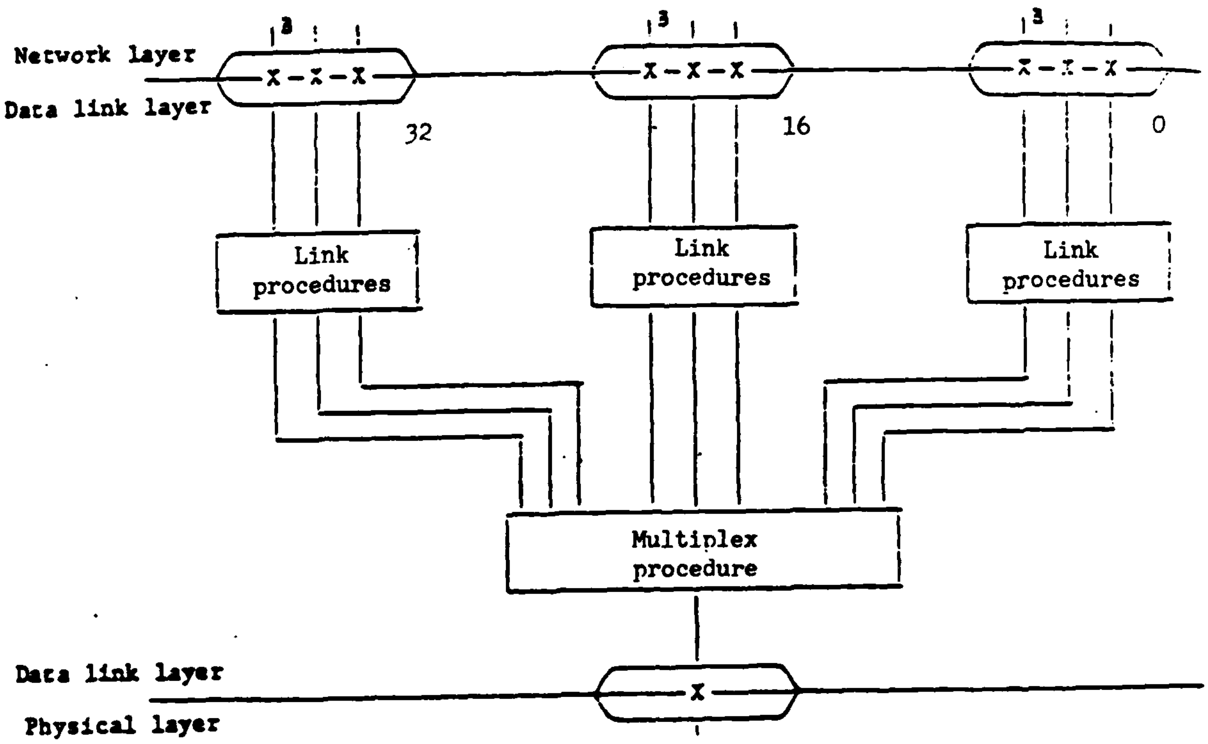


FIGURE 1-10/Q.920

Functional block diagram of data link layer

1.5.1 Link procedure

This procedure analyses the control field of the received frame (see Section 2) and provides appropriate peer-to-peer responses and layer-to-layer indications. In addition, it analyses the data link layer service primitives and transmits the appropriate peer-to-peer commands and responses.

1.5.2 Multiplex procedure

This procedure analyses the flag, Frame check sequence (FCS), and address octets of a received frame. If the frame is correct, it distributes the frame to the appropriate link procedural block based on the data link connection identifier (see sections 2.3 and 3.2).

On frame transmission, this procedure may provide data link layer contention resolution between the various link procedure blocks based on the SAPI, giving priority to signalling information.

1.5.3 Structure of link procedure

The functional model of the link procedure is shown in Figure 1-11/Q.920. The model consists of several functional blocks for point-to-point and broadcast connections. Each of these functional blocks consists of three functional entities, namely a transmission control, a reception control and a link state control.

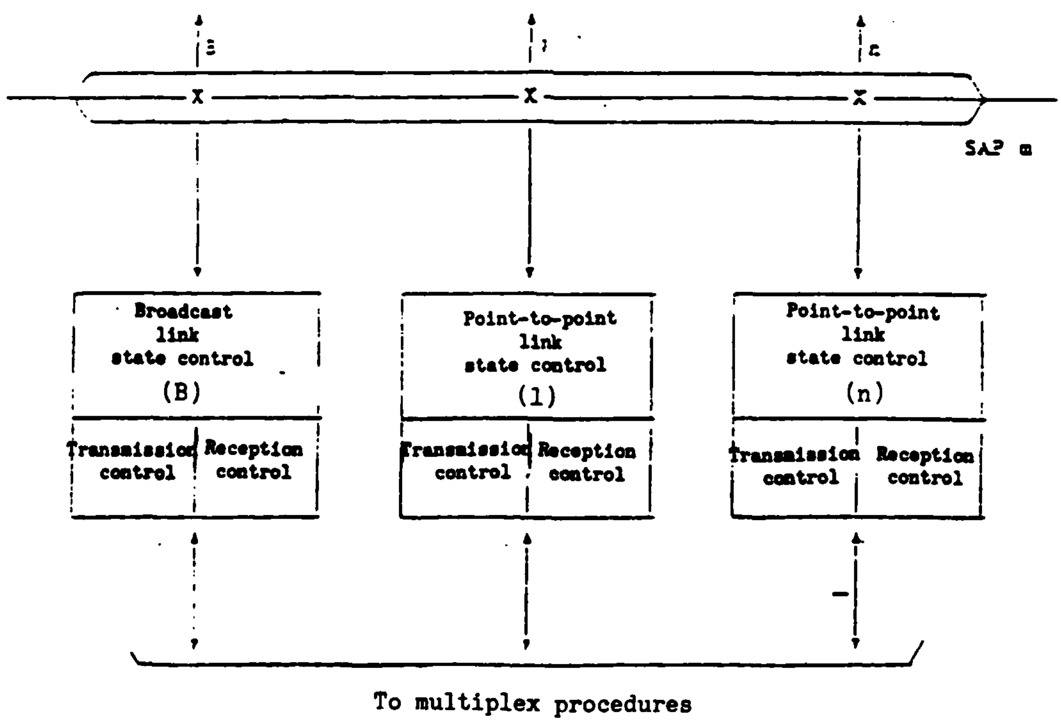


FIGURE 1-11/Q.920

Link procedure structure

2. Frame structure for peer-to-peer communication

2.1 General

All data link layer peer-to-peer exchanges are in frames conforming to one of the formats shown in Figure 2-1/Q.920. Two formats are shown in the figure, Format A for frames where there is no information field, and Format B for frames containing an information field.

2.2 Flag sequence

All frames shall start and end with the flag sequence consisting of one "0" followed by six contiguous "1"s and one "0". The flag preceding the address field is defined as the opening flag. The flag following the FCS field is defined as the closing flag.

2.3 Address field

The address field shall consist of two octets as illustrated in Figure 2-1/Q.920. The format of the address field is defined in section 3.2. Single octet address field is reserved for LAPB operation /‾3_7.

2.4 Control field

The control field shall consist of one or two octets. Figure 2-1/Q.920 illustrates two frame formats, each with the control field of one or two octets.

The format of the control field is defined in section 3.4.

2.5 Information field

The contents of the information field shall consist of an integer number of octets.

The maximum number of octets in the information field is defined in section 5.10.3.

2.6 Transparency

A transmitting data link layer entity shall examine the frame content between the opening and closing flag sequences, (address, control, information and FCS fields) and shall insert a "0" bit after all sequences of five contiguous "1" bits (including the last five bits of the FCS) to ensure that a flag or an abort sequence is not simulated within the frame. A receiving data link layer entity shall examine the frame contents between the opening and closing flag sequences and shall discard any "0" bit which directly follows five contiguous "1" bits.

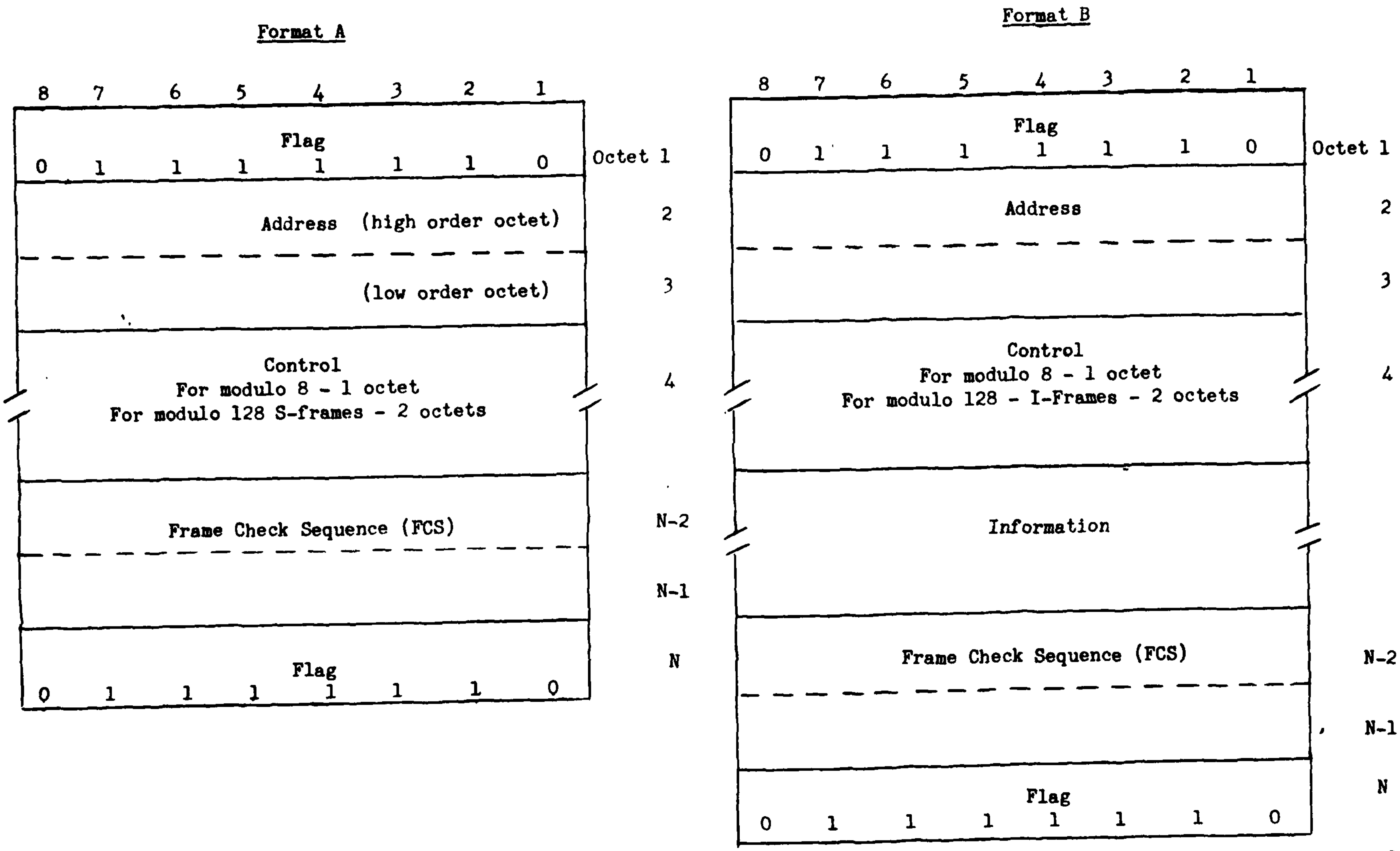


FIGURE 2-1/Q.920

Frame formats

2.7 Frame Checking Sequence (FCS)

The FCS shall be a sixteen-bit sequence. It shall be the ones complement of the sum (modulo 2) of :

a) The remainder of (x raised to k power) ($x^{15} + x^{14} + x^{13} + x^{12} + x^{11} + x^{10} + x^9 + x^8 + x^7 + x^6 + x^5 + x^4 + x^3 + x^2 + x^1 + 1$) divided (modulo 2) by the generator polynominal $x^{16} + x^{12} + x^5 + 1$, where k is the number of bits in the frame existing between, but not including, the final bit of the opening flag and the first bit of the FCS, excluding bits inserted for transparency, and

b) the remainder after multiplication by x^{16} and then division (modulo 2) by the generator polynominal $x^{16} + x^{12} + x^5 + 1$, of the content of the frame, existing between but not including, the final bit of the opening flag and the first bit of the FCS, excluding bits inserted for transparency.

As a typical implementation, at the transmitter, the initial remainder of the division is preset to all "1"s and is then modified by division by the generator polynominal (as described above) on the address, control and information fields; the "1"s complement of the resulting remainder is transmitted as the sixteen-bit FCS sequence.

As a typical implementation at the receiver, the initial remainder is preset to all "1"s. The final remainder after multiplication by x^{16} and division (modulus 2) by the generator polynominal $x^{16} + x^{12} + x^5 + 1$ of the serial incoming protected bits, will be 0001110100001111 (x^{15} through x^0, respectively) in the absence of transmission errors.

2.8 Format convention

2.8.1 Numbering convention

The basic convention used in this Recommendation is illustrated in Figure 2-2/Q.920. The bits are grouped into octets. The bits of an octet are shown horizontally and are numbered from 1 to 8. Multiple octets are shown vertically and are numbered from 1 to n.

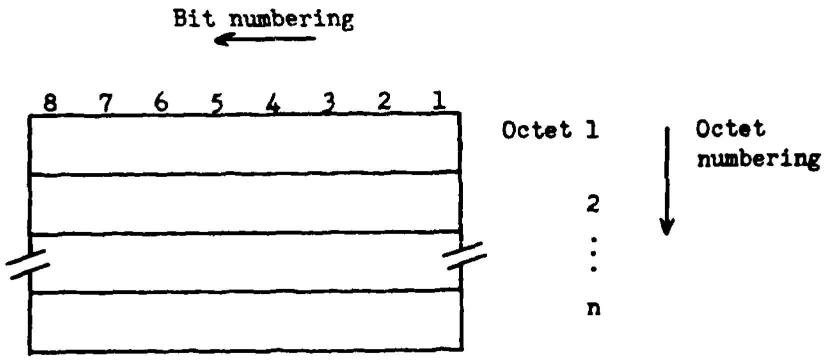


FIGURE 2-2/Q.920
Format convention

2.8.2 Order of bit transmission

The octets are transmitted in ascending numerical order; inside an octet bit 1 is the first bit to be transmitted.

2.8.3 Field mapping convention

When a field is contained within a single octet, the lowest bit number of the field represents the lowest order value.

When a field spans more than one octet, the order of bit values progressively decreases as the octet number increases within each octet. The lowest bit number associated with the field represents the lower order value.

For example, a bit number can be identified as a couple (o, b) where o is the octet number and b is the relative bit number within the octet. Figure 2-3/Q.920 illustrates a field that spans from bit (1, 3) to bit (2, 7). The high order bit of the field is mapped on bit (1, 3) and the low order bit is mapped on bit (2, 7).

8	7	6	5	4	3	2	1	
					2^4	2^3	2^2	1
2^1	2^0							2

FIGURE 2-3/Q.920

Field mapping convention

An exception to the preceding field mapping convention is the data link layer Frame Check Sequence (FCS) field, which spans two octets. In this case, bit 1 of the first octet is the high order bit and bit 8 of the second octet is the low order bit (Figure 2-4/Q.920).

8	7	6	5	4	3	2	1	
2^8							2^{15}	1
2^0							2^7	2

FIGURE 2-4/Q.920

FCS mapping convention

2.9 Corrupted frames

A corrupted frame is a frame which :

a) is not properly bounded by two flags, or

b) has fewer than five octets between flags, or

c) does not consist of an integral number of octets, or

d) contains an incorrect FCS.

Corrupted frames shall be discarded without notification to the sender.

2.10 Invalid frames

Frames may be invalid for procedural reasons, as defined in sections 3.6.12 and 5.9.3.

2.11 Frame abortion

Receipt of seven or more contiguous "1" shall be interpreted as an abort and the receiving data link layer entity shall ignore the frame.

The need and method of frame abortion on the sender side is a subject for further study.

3. Elements of procedure and format of fields for data link layer peer-to-peer communication

3.1 General

The elements of procedure define the commands and responses that are used on the data link connections carried on the D-channel.

Procedures are derived from these elements of procedure and are described in section 5.

3.2 Address field format

The address field format shown in Figure 3-1/Q.920 contains the address field extension bit(s), a command/response indication bit, a data link layer service access point identifier (SAPI) subfield, and a terminal endpoint identifier (TEI) subfield.

8	7	6	5	4	3	2	1	
S A P I						C/R	EA 0	Octet 2
T E I							EA 1	3

EA = Extended address field bit
C/R = Command response field bit
SAPI = Service access point identifier
TEI = Terminal endpoint identifier

Note - Single octet address field is reserved for LAPB operation.

FIGURE 3-1/Q.920

Address field format

3.3 Address field variables

3.3.1 Extended address field bit (EA)

The address field range is extended by reserving the first transmitted bit of the address field octets to indicate the final octet of the address field. The presence of a "1" in the first bit of an address field octet signals that it is the final octet of the address field. The double octet address field for LAPD operation shall have bit 1 of the first octet set to a "0" and bit 1 of the second address octet set to "1".

3.3.2 Command/Response field bit (C/R)

The C/R bit identifies a frame as either a command or a response. The user will send commands with the C/R bit set to "0", and responses with the C/R bit set to "1". The network will do the opposite; i.e., commands are sent with C/R set to "1", and responses are sent with C/R set to "0". The combinations for the network and user are shown in Figure 3-2/Q.920.

	Network side C/R value	User side C/R value
Commands from	1	0
Responses to	1	0
Commands to	0	1
Responses from	0	1

FIGURE 3-2/Q.920

C/R usage

In conformance to HDLC rules, commands use the other statfon's address while responses use own station's addresses. According to these rules, the addresses of the network and user side take the form :

	C/R	SAPI	TEI
Network	0	X	Y
User	1	X	Y

where X and Y conform to the definition contained in sections 3.3.3 and 3.3.4.

3.3.3 Service access point identifiers (SAPI)

The service access point identifier (SAPI) specifies a data link layer entity that should process a data link layer frame. The SAPI allows one of 64 service access points to be specified, where bit 3 of the address field is the least significant binary digit value and bit 8 is the most significant. The SAPI values are allocated as follows :

SAPI Value	Layer 3 entity
0	Circuit-switched procedures
16	Packet-switched procedures
32–47	Reserved for national use
63	Management procedures (see Note 1)
All others	Reserved for future standardization

Note 1 - Depending on the outcome of studies on testing and maintenance, a specific SAPI may be allocated or an already defined SAPI may also be used for these functions.

Note 2 - Other layer 3 entity assignments are a subject for further study.

3.3.4 Terminal endpoint identifier (TEI)

The terminal endpoint identifier (TEI) for a point-to-point data link connection may be associated with a single TE. A TE may contain one or more TEIs. The TEI for a broadcast link is associated with all user side data link layer entities containing the same SAPI. The TEI subfield allows 128 values where bit 2 of the address field octet containing the TEI is the least significant binary digit and bit 8 is the most significant binary digit value. The following conventions shall apply in the assignment of these values.

3.3.4.1 TEI for broadcast data link connection

The TEI subfield bit pattern "111 1111" (binary value = 127) is defined as the group TEI. The group TEI is assigned to the broadcast data link connection associated with the addressed SAP.

3.3.4.2 TEI for point-to-point data link connection

The remaining TEI values are used for the point-to-point data link connections associated with the addressed SAP. The range of TEI values shall be allocated in the following manner :

TEI Value	User type
0-63 :	Non-automatic assignment user equipment
64-126 :	Automatic assignment user equipment

3.4 Control field formats

The control field identifies the type of frame, which will be either c and or response. The control field will contain sequence numbers where applicable.

Three types of control field formats are used for numbered information frames (I frames), supervisory frames (S frames), and unnumbered frames (U frames). The control field formats for basic (modulo 8) operation and extended (modulo 128) operation are shown in Figure 3-3/Q.920.

3.4.1 Information transfer format - I

The I format shall be used to perform an information transfer between layer 3 entities. The functions of N(S), N(R) and P/F (defined in section 3.5) are independent; i.e., each I frame has an N(S) sequence number and an N(R) sequence number which may or may not acknowledge additional I frames received by the data link layer entity. The P bit may be set to binary "0" or "1". The use of P, N(S) and N(R) is defined in section 5.

3.4.2 Supervisory format - S

The S format shall be used to perform link supervisory control functions : to acknowledge I frames, to request retransmission of I frames, and to request a temporary suspension of transmission of I frames.

Each S frame has an N(R) sequence number which may or may not acknowledge additional I frames received by the data link layer entity. The P/F bit may be set to binary "0" or binary "1".

An S format frame shall not contain an information field.

3.4.3 Unnumbered format - U

The U format shall be used to provide additional link control functions and unnumbered information transfers. This format does not contain sequence numbers but includes a P/F bit that may be set to binary "0" or binary "1".

3.5 Control field parameters and associated state variables

The various parameters associated with the control field are described in this section. The coding of the bits within these parameters is such that the lowest numbered bit within the parameter field is the least significant bit.

Control field bits (modulo 8)	8	7	6	5	4	3	2	1	
I frame	N(R)			P	N(S)			0	Octet 1
S frame	N(R)			P/F	S	S	0	1	Octet 1
U frame	M	M	M	P/F	M	M	1	1	Octet 1

Control field bits (modulo 128)	8	7	6	5	4	3	2	1	
I frame	N(S)							0	Octet 1
	N(R)							P	2
S frame	X	X	X	X	S	S	0	1	Octet 1
	N(R)							P/F	2
U frame	M	M	M	P/F	M	M	1	1	Octet 1

N(S) Transmitter send sequence number

N(R) Transmitter receive sequence number
S Supervisory function bit
M Modifier function bit
P/F Poll bit when issued as a command, final bit when issued as a response
X Reserved and set to 0

FIGURE 3-3/Q.920

Control field formats

3.5.1 Modulus

Each I frame is sequentially numbered and may have the value 0 through "n" minus 1 (where "n" is the modulus of the sequence numbers). The modulus equals 8 or 128 and the sequence numbers cycle through the entire range, 0 through 7 or through 127.

3.5.2 Multiple frame operation - variables and sequence numbers

3.5.2.1 Poll/Final bit

The Poll/Final (P/F) bit serves a function in both command frames and response frames. In command frames the P/F bit is referred to as the P bit. In response frames it is referred to as the F bit.

The use of the P/F bit is described in the procedure for use of the P/F bit in sections 5.1 and 5.6.

3.5.2.2 Send state variable V(S)

Each point-to-point data link connection endpoint shall have an associated send state variable (V(S)) when using commands/responses contained in the I and S frames. The send state variable denotes the sequence number of the next in-sequence I frame to be transmitted or re-transmitted. The send state variable can take on the value 0 through modulus minus 1. The value of the send state variable shall be incremented by 1 with each successive I frame transmission or re-transmission, and shall not exceed V(A) by more than the maximum number of outstanding I frames k. The value of k may be in the range of $1 \leqslant k \leqslant 7$ for basic (modulo 8) operation and $1 \leqslant k \leqslant 127$ for extended (modulo 128) operation.

3.5.2.3 Acknowledged state variable V(A)

Each point-to-point data link connection endpoint shall have an associated acknowledged state variable (V(A)) when using commands/responses contained in the I and S frames. The acknowledged state variable denotes the last frame that has been acknowledged by its peer (V(A)-1 equals the N(S) of last acknowledged frame). The acknowledged state variable can take on the value 0 through modulus minus 1. The value of the acknowledged state variable shall be updated by the valid N(R) values received from its peer (see section 3.5.2.6). A valid N(R) value is one that is in the range $V(A) \leqslant N(R) \leqslant X$ (internal state variable) in the timer recovery condition (see section 5.7.7).

3.5.2.4 Send sequence number N(S)

Only I frames contain N(S), the send sequence number of transmitted I frames. Prior to transmission of an in-sequence I frame, the value of N(S) is set equal to the value of the send state variable V(S).

3.5.2.5 Receive state variable V(R)

Each point-to-point data link connection endpoint shall have an associated receive state variable (V(R)) when using commands/responses contained in the I and S frames. The receive state variable denotes the sequence number of the next in-sequence I frame to be received. The receive state variable can take on the value "0" through modulus minus 1 and shall be incremented by one with the receipt of an error free, in-sequence I frame whose send sequence number N(S) equals the receive state variable

3.5.2.6 Receive sequence number N(R)

All I and S format frames contain N(R). Prior to transmission of I or S frames, the value N(R) is set equal to the current value of the receive state variable (V(R)). N(R) indicates that the data link layer entity transmitting the N(R) has correctly received all I frames numbered up to and including N(R) - 1.

3.5.3 Single frame operation variables and parameters

3.5.3.1 Poll/Final bit

The Poll/Final (P/F) bit serves a function in both command and response frames. In command frames the P/F bit is referred to as the P bit. In response frames it is referred to as the F bit.

3.5.3.2 Poll bit state variable V(P)

Each point-to-point data link connection endpoint shall have an associated poll bit state variable V(P) when using TBN commands or responses in single frame operation. The poll bit state variable V(P) shall denote the value N(P) of the poll bit in the next in-sequence TBN command frame to be transmitted. The value of V(P) shall be complemented each time a transmitted TBN frame is correctly acknowledged. V(P) shall be reset in accordance with the procedures defined in section 5.5.4.

3.5.3.3 Final bit state variable V(F)

Each point-to-point data link connection endpoint shall have an associated final bit state variable V(F) when using TBN commands or responses in single frame operation. The final bit state variable V(F) shall denote the value N(F) of the final bit in the next TBN response frame to be transmitted to acknowledge a correctly received TBN command frame. If the poll bit in the received TBN frame is equal to the current value of V(F), the value of the V(F) shall be complemented. The value of V(F) shall be reset in accordance with the procedures defined in section 5.5.3.

3.6 Commands and responses

The following commands and responses are used by either the user or the network data link layer entities and are represented in Figures 3-4/Q.920 and 3-5/Q.920. Each data link connection uses an appropriate subset of these commands and responses.

The commands and responses are as follows :

3.6.1 Information (I) command

The function of the information (I) command is to transfer across a data link connection sequentially numbered frames containing information fields provided by the layer 3. This command is used in multiple frame operation on point-to-point data link connection.

Format	Commands	Responses	Encoding 8	7	6	5	4	3	2	1
Information transfer	I (information)		N(R)			P	N(S)			0
Supervisory	RR (receive ready)	RR (receive ready)	N(R)			P/F	0	0	0	1
	RNR (receive not ready)	RNR (receive not ready)	N(R)			P/F	0	1	0	1
	REJ (reject)	REJ (reject)	N(R)			P/F	1	0	0	1
Unnumbered	SABM (set asynchronous balance mode)		0	0	1	P	1	1	1	1
		DM (disconnected mode)	0	0	0	F	1	1	1	1
	TBN (to be named)	TBN (to be named)	1	1	0	P/F	0	0	1	1
	UI (unnumbered information)		0	0	0	P	0	0	1	1
	DISC (disconnect)		0	1	0	P	0	0	1	1
		UA (unnumbered acknowledgement)	0	1	1	F	0	0	1	1
		FRMR (frame reject)	1	0	0	F	0	1	1	1

FIGURE 3-4/Q.920

Commands and responses - basic (modulo 8) operation

Format	Commands	Responses	8	7	6	5	4	3	2	1	
Information transfer	I (information)		N(S)							0	Octet 1
			N(R)							P	2
Supervisory	RR (receive ready)	RR (receive ready)	0	0	0	0	0	0	0	1	Octet 1
			N(R)							P/F	2
	RNR (receive not ready)	RNR (receive not ready)	0	0	0	0	0	1	0	1	Octet 1
			N(R)							P/F	2
	REJ (reject)	REJ (reject)	0	0	0	0	1	0	0	1	Octet 1
			N(R)							P/F	2
Unnumbered	SABME (set asynchronous balanced mode extended)		0	1	1	P	1	1	1	1	
		DM (disconnected mode)	0	0	0	F	1	1	1	1	
	TBN (to be named)	TBN (to be named)	1	1	0	P/F	0	0	1	1	
	UI (unnumbered information)		0	0	0	P	0	0	1	1	
	DISC (disconnect)		0	1	0	P	0	0	1	1	
		UA (unnumbered acknowledgement)	0	1	1	F	0	0	1	1	
		FRMR (frame reject)	1	0	0	F	0	1	1	1	

FIGURE 3-5/Q.920

Commands and responses - extended (modulo 128) operation

3.6.2 Set asynchronous balanced mode (SABM) and set asynchronous balanced mode extended (SABME) commands

The SABM/SABME unnumbered command is used to place the addressed user side and the network side data link layer connection into multiple frame operation.

No information field is permitted with the SABM/SABME commands. A data link layer entity confirms acceptance of SABM/SABME by the transmission at the first opportunity of a UA response. Upon acceptance of this command the data link layer entity's send state variable V(S), acknowledged state variable V(A), and receive state variable V(R) are set to 0.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged and are not retransmitted.

3.6.3 Disconnect (DISC) command

The DISC unnumbered command shall be transmitted to terminate the multiple frame operation.

No information field is permitted with the DISC command. Prior to actioning the command, the data link layer entity receiving the DISC confirms the acceptance of a DISC by the transmission of a UA response. The data link layer entity sending the DISC terminates the multiple frame operation when it receives the acknowledging UA or DM response.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged and are not retransmitted by the data link layer entities.

3.6.4 Unnumbered information (UI) command

When a layer 3 or management entity requests unacknowledged information transfer, the UI command shall be used to send information to its peer without affecting data link layer variables. These UI command frames, transmitted via a data link connection, do not carry a sequence number; therefore, the UI frame may be lost without notification to layer 3 if a data link exception occurs during transmission of the command.

3.6.5 "To be named" (TBN) command

The function of the "to be named" (TBN) command is to transfer information between data link layer entities using sequentially acknowledged frames containing information fields provided by layer 3. TBN commands are sequence-verified by the use of the P/F bit. This command is used in single frame operation on point-to-point data links. The TBN frame may be lost without notification to layer 3 if a data link exception condition occurs during transmission of the command, or during a reply to the command when the V(P) and the V(F) variables are out of step.

3.6.6 Receive ready (RR) command/response

The receive ready (RR) supervisory frame is used by a data link layer entity to :

a) indicate it is ready to receive an I frame;

b) acknowledge previously received I frames numbered up to and including N(R) - 1 (as defined in section 5);

c) clear a busy condition that was indicated by the previous transmission of an RNR frame.

In addition to indicating the status of a data link layer entity, the RR command with P bit set to "1" may be used by the data link layer entity to ask for the status of its peer.

3.6.7 Reject (REJ) command/response

The reject (REJ) supervisory frame is used to request retransmission of I frames starting with the frame numbered N(R). The value of N(R) in the REJ frame acknowledges frames numbered up to and including N(R) - 1. New I frames pending initial transmission shall be transmitted following the retransmitted I frame(s).

Only one REJ exception condition for a given direction of information transfer shall be established at a time. The REJ exception condition is cleared (reset) upon the receipt of an I frame with an N(S) equal to the V(R) of the REJ. The REJ condition is also reset upon the receipt of a mode setting command (SABM/SABME or DISC).

The transmission of REJ shall also indicate the clearance of any busy condition with the sending data link layer entity.

In addition to indicating the status of a data link layer entity, the REJ command with P bit set to "1" may be used by the data link layer entity to ask for the status of its peer.

3.6.8 Receive not ready (RNR) command/response

The receive not ready (RNR) supervisory frame shall be used by a data link layer entity in the user side or network side to indicate a busy condition; that is, temporary inability to accept additional incoming I frames. The value of N(R) in the RNR frame acknowledges I frames numbered up to and including N(R) - 1. I frame N(R) and subsequent I frames received, if any, are to be acknowledged; the acknowledgement of these I frames will be indicated in subsequent exchanges. The data link layer entity originating the RNR shall indicate the clearance of the busy condition by trnasmission of RR. Alternatively the condition may be cleared by the transmission of SABM/SABME, UA, or REJ.

In addition to indicating the status of a data link layer entity, the RNR command with P bit set to "1" may be used by the data link layer entity to ask for the status of its peer.

3.6.9 Unnumbered acknowledgement (UA) response

The UA response is used to acknowledge the receipt and acceptance of the U format set mode commands (SABM/SABME or DISC). Received U format set mode commands are not actioned until the UA response is transmitted. No information field is permitted with the UA response.

3.6.10 Disconnected mode (DM) response

The DM response is used by a data link layer entity to report to its peer that the data link layer is in a state where multiple frame operation cannot be performed. No information field is permitted with the DM response. A data link layer entity shall transmit a DM response to any command which it cannot action.

3.6.11 "To be named" (TBN) response

The TBN response is used to acknowledge the receipt of a TBN command, when the data link connection is operating in single frame operation. There is no I field contained in a TBN response.

3.6.12 Frame reject (FRMR) response

The FRMR response may be used by a data link layer entity, when operating in multiple frame operation, to report an error condition not recoverable by retransmission of the identical frame; that is, one of the following conditions, which results from the receipt of a frame without errors indicated in section 2.9 :

a) an error free frame which is unknown as a command or response;

b) an invalid frame format;

c) an invalid N(R) condition;

d) an information field which exceeds the maximum information field length which can be accommodated.

A valid N(R) value is one that is in the range $V(A) \leq N(R) \leq V(S)$ in the normal condition or frame rejection condition or $V(A) \leq N(R) \leq X$ internal state variable when in the timer recovery condition.

An information field which immediately follows the control field and consists of three or five octets (modulo 8 (basic) operation or modulo 128 (extended) operation, respectively), is returned with this response and provides the reason for the FRMR response. This information field format is given in Figures 3-6/Q.920 and 3-7/Q.920.

8	7	6	5	4	3	2	1	
Rejected control field								Octet 5
V(R)			C/R	V(S)			0	6
0	0	0	0	Z	Y	X	W	7

- "Rejected control field" is the control field of the received frame which caused the frame reject.
- V(S) is the current send state variable value in the user or network reporting the rejection condition.
- V(R) is the current receive state variable value in the user or network reporting the rejection condition.
- C/R is set to 1 if the frame rejected was a response, and set to 0 if the frame rejected was a command.

- W set to 1 indicates that the control field received and returned in octet 5 was invalid or not implemented.
- X set to 1 indicates that the control field received and returned in octet 5 was considered invalid because the frame contained an information field which is not permitted or is an S or U frame with incorrect length. Bit W must be set to 1 in conjunction with this bit.
- Y set to 1 indicates that the information field received exceeded the maximum established capacity of the user or network reporting the rejection condition.
- Z set to 1 indicates that the control field received and returned in octet 5 contained an invalid N(R).

- Octet 6 bit 1 and octet 7 bits 5 through 8 shall be set to "0".

FIGURE 3-6/Q.920

FRMR Information field format basic (modulo 8) operation

8	7	6	5	4	3	2	1	
Rejected frame								Octet 5
Control field								6
V(S)							0	7
V(R)							C/R	8
0	0	0	0	Z	Y	X	W	9

- "Rejected control field" is the control field of the received frame which caused the frame reject, When the rejected frame is a U format frame, the control field of the rejected frame is positioned in octet 5, with octet 6 set to 0000 0000.
- V(S) is the current send state variable value in the network or user reporting the rejection condition.
- C/R set to 1 indicates the rejected frame was a response. C/R set to 0 indicates the rejected frame was a command.
- V(R) is the current receive state variable value in the network or user reporting the rejection condition.
- W set to 1 indicates that the control field received and returned in octets 5 and 6 was invalid or or not implemented.
- X set to 1 indicates that the control field received and returned in octets 5 and 6 was considered invalid because the frame contained an information field which is not permitted with this frame or is an S format or U format frame with incorrect length. Bit W must be set to 1 in conjunction with this bit.
- Y set to 1 indicates that the information field received exceeded the maximum established capacity of the user or network reporting this condition.
- Z set to 1 indicates the control field received and returned in octets 5 and 6 contained an invalid N(R).
- Octet 7, bit 1 and octet 9, bits 5 through 8 shall be set to "0".

FIGURE 3-7/Q.920

FRMR Information field format
extended (modulo 128) operation

4. Elements for layer-to-layer communication

4.1 General

Communications between layers and, for this recommendation, between the data link layer and the management entity are accomplished by means of primitives.

Primitives represent, in an abstract way, the logical exchange of information and control between the data link and adjacent layers. They do not specify or constrain the implementation of entities or interfaces.

Primitives consist of commands and their respective responses associated with the services requested of a lower layer. The general syntax of a primitive is :

XX_Generic name_Type : Parameters

Where XX designates the layer providing the service. For this Recommendation XX is either DL for the data link layer, PH for the physical layer, or MDL for the management entity to the data link layer interface.

Note 1 - The full definition as to specifying the management entity to the data link layer interface is a subject for further study.

Note 2 - For better understanding, the semantics of primitives will be improved in the next study period (Question Q/XI).

4.1.1 Generic names

The generic name specifies the activity that the addressed layer should perform. Tables 1/Q.920 illustrates the primitives defined in this Recommendation. Note that not all primitives have associated parameters.

The primitive generic names that are defined in this Recommendation are :

4.1.1.1 DL-ESTABLISH

The DL-ESTABLISH primitives are used to request and indicate the outcome of the procedures for establishing single or multiple frame operation.

4.1.1.2 DL-RELEASE

The DL-RELEASE primitives are used to request and indicate the outcome of the procedures for terminating a previously established single or multiple frame operation. In the case of a data link layer malfunction, layer 3 will be notified by a RELEASE indication.

4.1.1.3 DL-DATA

The DL-DATA primitives are used to pass layer 3 messages to and from the data link layer which are to be transmitted, or have been received, using acknowledged operation.

4.1.1.4 DL-UNIT DATA

The DL-UNIT DATA primitives are used to pass layer 3 messages to and from the data link layer which are to be transmitted, or have been received, using the unacknowledged mode of information transfer.

4.1.1.5 MDL-ASSIGN

The MDL-ASSIGN primitives are used by the management entity to request that the data link layer associate the TEI contained within the message portion of the primitive with the specified connection endpoint(s). The data link layer indicates to the management entity the need for a TEI value.

4.1.1.6 MDL-REMOVE

The MDL-REMOVE primitives are used by the management entity to request that the data link layer remove the association of the specified TEI value with the specified connection endpoints. The TEI and connection endpoints are specified by the REMOVE primitive message unit.

4.1.1.7 MDL-ERROR

The MDL-ERROR primitives are used to notify the management entity that an error has occurred, associated with a previous management function request or detected as a result of communication with the data link layer peer entity, which cannot be corrected by the data link layer. The management entity may respond with an ERROR primitive if the management entity cannot obtain a TEI value.

4.1.1.8 MDL-UNIT DATA

The MDL-UNIT DATA primitives are used to pass management entity messages to and from the data link layer which are to be transmitted, or have been received, using the unacknowledged mode of information transfer.

4.1.1.9 PH-DATA

The PH-DATA primitives are used to pass to and receive from the physical layer, message units containing frames used for data link layer peer-to-peer communications.

4.1.1.10 PH-ACTIVATE

The PH-ACTIVATE primitives are used to indicate that the physical layer has been activated. The REQUEST option is for further study.

4.1.1.11 PH-DEACTIVATE

The PH-DEACTIVATE primitives are used to indicate that the physical layer has been deactivated. The REQUEST option is for further study.

Note - The provision of additional primitives is for further study.

4.1.2 Primitive types

The primitive types defined in this Recommendation are :

4.1.2.1 REQUEST

The REQUEST primitive type is used when a higher layer is requesting a service from the next lower layer.

4.1.2.2 INDICATION

The INDICATION primitive type is used by a layer providing a service to notify the next higher layer of activities related to the REQUEST primitive type.

4.1.2.3 RESPONSE

The RESPONSE primitive type is used by a layer to acknowledge receipt, from a lower layer, of the INDICATION primitive type.

4.1.2.4 CONFIRM

The CONFIRM primitive type is used by the layer providing the requested service to confirm that the activity has been completed.

Figure 4-1/Q.920 illustrates the relationship of the primitive types to the layer 3 and data link layer.

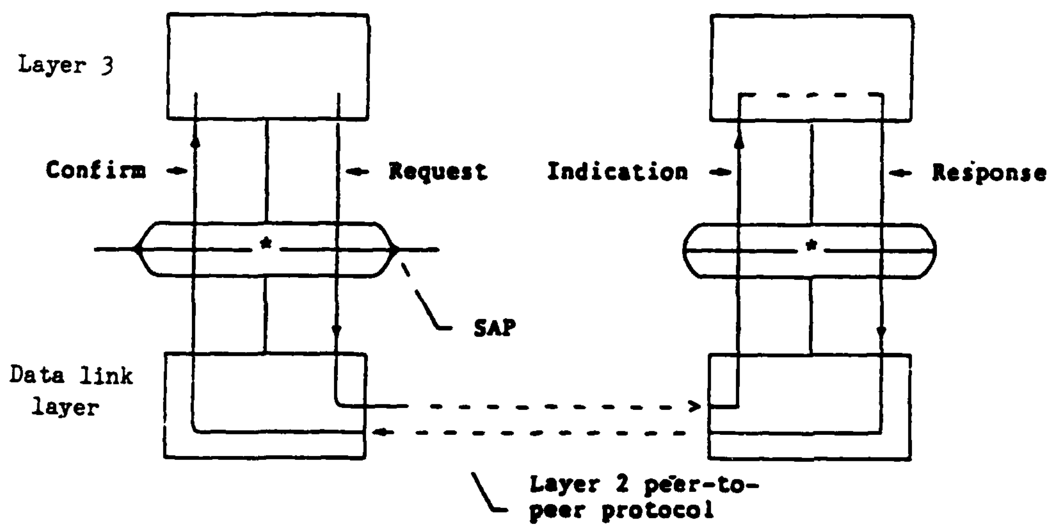


FIGURE 4-1/Q.920

Relationship of the primitive types to the layer 3 and the data link layer

4.1.3 Parameter definition

4.1.3.1 Priority indicator

Since several SAPs may exist within a network or a user, protocol messages units sent by one SAP may contend with those of other service access points for the physical resources available for message transfer. The priority indicator is used to determine which message unit will have greater priority when contention exists.

TABLE 4-1/Q.920

Primitives associated with the data link layer

Generic name	Type				Parameters		Message unit contents
	Request	Indication	Response	Confirm	Priority indicator	Message unit	
L3 ↔ L2							
DL-ESTABLISH	X	X	*	*	-	*	choice of single/multiple frame operation
DL-RELEASE	X	X	*	*	-	*	choice of single/multiple frame operation
DL-DATA	X	X	-	-	-	X	network layer peer-to-peer message
DL-UNITDATA	X	X	-	-	-	X	
M ↔ L2							
MDL-ASSIGN	X	X	-	*	-	X	TEI value
MDL-REMOVE	X		-	*	-	X	TEI value
MDL-ERROR	-	X	X	-	-	X	Reason for error message
MDL-UNITDATA	X	X	-	-	-	X	Management function peer-to-peer message
L2 ↔ L1							
PH-DATA	X	X	-	-	X	X	Data link layer peer-to-peer message
PH-ACTIVATE	*	X	-	-	-	-	
PH-DEACTIVATE	*	X	-	-	-	-	

* For further study

L3 ↔ L2 : Layer 3/data link layer boundary
M ↔ L2 : Management entity/data link layer boundary
L2 ↔ L1 : Data link layer/physical layer boundary

4.1.3.2 *Message* unit

The message unit contains additional layer-to-layer information concerning actions and results associated with requests. In the case of the data primitive, the message unit contains the requesting layer peer-to-peer messages. For example DL-DATA message unit contains layer 3 information. The PH-DATA message unit contains the data link frame.

Note - The operations across the data link layer 3 boundary shall be such that the layer sending the DATA or UNITDATA primitive can assume a temporal order of the bits within the message unit and that the layer receiving the primitive can reconstruct the message with its assumed temporal order.

4.2 Primitive procedures

A subject for further study.

5 Definition of the peer-to-peer procedures of the data link layer

The procedures for use by the data link layer are specified in the following sections. The need for additional procedure sets is for further study.

The elements of procedure (frame types) which apply are :

a) for unacknowledged information transfer (section 5.2)

UI-command

b) for single frame acknowledged information transfer (section 5.5)

TBN-command/response

c) for multiple frame acknowledged information transfer (sections 5.6 to 5.10)

SABM/SABME-command

UA-response

DM-response

DISC-command

RR-command/response

RNR-command/response

REJ-command/response

I-command

FRMR-response.

5.1 Procedure for the use of the P/F bit

5.1.1 Immediate response operation

A data link layer entity receiving an SABM, SABME, DISC, RR, RNR, or REJ I frame with the P bit set to 1, shall set the F bit to 1 in the next response frame it transmits as defined in Table 5-1/Q.920 below :

TABLE 5-1/Q.920

Immediate response operation of P/F bit

Command received with P bit = 1	Response transmitted with F bit = 1
SABM, SABME, DISC	UA, DM
I, RR, RNR, REJ	RR, RNR, REJ, FRMR, DM

5.1.2 Single frame operation

When in the single frame operation the bit provides a function similar to sequence numbers.

5.2 Procedures for unacknowledged information transfer

5.2.1 General

The procedures which apply to the transmission of information in unacknowledged operation are defined below.

No data link layer error recovery procedures are defined for unacknowledged operation.

5.2.2 Transmission of unacknowledged information

Unacknowledged information is passed to the data link layer by layer 3 using the primitive DL-UNITDATA-REQUEST. The layer 3 message unit shall be transmitted in UI command frames.

For broadcast operation, the TEI value shall be set to 127 (binary 111 1111, the group value).

For point-to-point operation the appropriate TEI value shall be used.

The Poll bit shall be set to binary "0".

5.2.3 Receipt of unacknowledged information

On receipt of a UI frame with a SAPI which is supported by the user, the contents of the information field shall be passed to the layer 3 using the data link layer to the layer 3 primitive DL-UNITDATA-INDICATION. Otherwise the UI frame shall be disregarded.

5.3 Assignment and removal of terminal endpoint identifier (TEI)

5.3.1 General

A user equipment in the TEI-unassigned state shall use the TEI assignment procedures to enter the TEI-assigned state. Conceptually these procedures exist in the management entity. The management entity on network side is referred to as the Assignment Source Point (ASP) in this Recommendation.

The purpose of this procedure is to :

a) allow a user equipment to request the network to select a TEI value that the data link layer entities within the requesting user equipment will use in their subsequent communications;

b) allow a user equipment to request the network to verify a TEI value already present in the user equipment, which the data link layer entities within the requesting user equipment will use in their subsequent communications;

c) allow a network to remove a previously assigned TEI from specific or all user equipments.

Additionally, the user management entity may instruct the data link layer entity to remove a TEI value for its own internal reasons. The management intity shall use the MDL-REMOVE-REQUEST for this purpose. Conditions under which this would occur are for further study.

Note - Subject to further study, internal reasons may include :

a) gaining or regaining the ability to communicate with the network ;

b) initialization from a no-power condition;

c) status of the physical layer (or whether it is plugged into or re-plugged into the interface);

d) local monitoring or detection of malfunctions;

e) others.

Section 5.3.4.1 includes the actions taken by a data link layer entity receiving a MDL-REMOVE-REQUEST.

Typically, one TEI value would be used by the user equipment (i.e. a data link layer entity which has been assigned a TEI value could use that value for all SAPs which it supports). If required, a number of TEI values may be requested by multiple use of the procedures defined in section 5.3.2. It shall be the responsibility of the user to maintain the association between TEI and SAPI values.

The initiation of these procedures occurs on the receipt of DL-ESTABLISH-REQUEST from the network layer while in the TEI unassigned state. The data link layer entity shall inform the management entity by using the MDL-ASSIGN-INDICATION. Alternatively, the management may initiate these procedures for its own reasons.

All management entity messages used for these procedures are transmitted to, or received from, the data link layer entity using the MDL-UNITDATA-REQUEST or INDICATION respectively.

The data link layer entity shall transmit MDL-UNITDATA-MESSAGES in UI frames. The SAPI value shall be 63. The TEI value shall be 127.

5.3.2 TEI assignment procedure

Upon initiation of the procedure, the management entity shall transmit a message containing the following elements :

a) Message type = Identity request

b) Request reference number (Ri)

c) Action indicator (Ai).

The Request reference number Ri shall be used to differentiate between a number of user equipments which may simultaneously request initialization of the TEI value. Ri shall be 2 octets in length and shall be generated by the user equipments.

The single octet Action indicator Ai shall be used to indicate a request to the Assignment Source Point (ASP) for the assignment of either any TEI value available, or a preferred TEI value.

The coding of the Ai shall be as follows :

a) Ai = Group address TEI (127):
This Ai value requests the ASP to assign any TEI value.

b) Ai = Preferred TEI:
This Ai value requests the ASP to verify the preferred TEI value

A timer T202 shall be started.

The ASP, on receipt of the Identity request message shall either :

a) select and verify a TEI value if no preferred value was indicated; or,

b) verify the indicated preferred value.

Verification shall be on the basis of information stored at the ASP and/or by means of the check routines defined in section 5.3.3.

The ASP, after having selected/verified the TEI value, shall transmit a message containing the following elements :

a) Message type = Identity assigned;
b) Request reference number Ri;
c) the assigned TEI value in the Ai field.

The user management entity receiving this message shall inform the data link layer by means of MDL-ASSIGN-REQUEST.

The user data link layer entity shall :

a) enter the TEI assigned state;
b) set the TBN frame variables, V(P) and V(F), if appropriate;
c) continue with link establishment procedures if a DL-ESTABLISH-REQUEST is outstanding.

If a TEI is not available (or the preferred TEI value is not available), the ASP shall transmit a message containing the following elements :

a) Message type = Identity denied
b) Request reference number Ri
c) the value of TEI which is denied in the Ai field (a value of 127 indicates that no TEIs are available).

The user management entity receiving the Identity denied message may reinvoke the assignment procedures to obtain a TEI value; but otherwise, the management entity shall inform the data link layer entity using MDL-ERROR-RESPONSE. The data link layer entity receiving MDL-ERROR-RESPONSE shall inform layer 3 using the primitive DL-RELEASE-INDICATION.

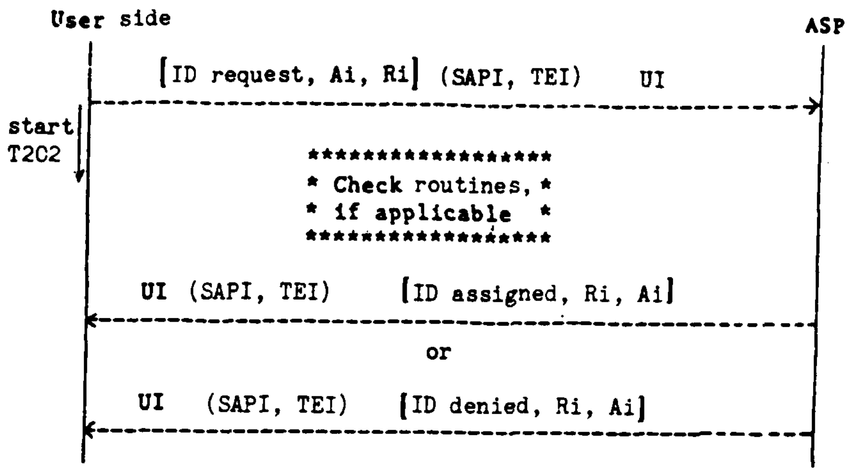
5.3.2.1 Expiry of Timer T202

If the user receives no response to its Identity request message within T202, the timer shall be reset and the Identity request message shall be retransmitted.

After N202 retransmissions the management entity shall inform the data link layer entity using MDL-ERROR-RESPONSE. The data link layer entity receiving MDL-ERROR-RESPONSE shall inform layer 3 using the primitive DL-RELEASE-INDICATION.

The value of T202 is specified in section 5.10.6. The value of N202 is for further study.

The TEI assignment procedure is illustrated in Figure 5-1/Q.920.



SAPI = Service access point identifier = 63.
TEI = group TEI = 127
ID request = Identity request
ID denied = identity denied
Ai = action indicator, see Table 5-2/Q.920
Ri = Reference number
( ) = Contents of the data link layer address field
[ ] = Contents of the Information field

FIGURE 5-1/Q.920

TEI assignment procedure

5.3.3 Check routine procedure

5.3.3.1 Use of the check routine procedure

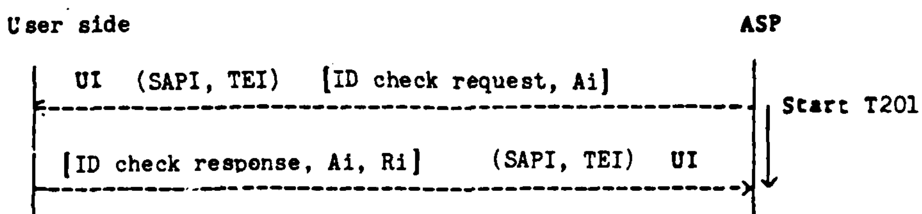
The check routine procedure may be used in the following cases :

a) in connection with an Identity request, as described in section 5.3.2;

b) for updating of TEI status data, as an audit procedure.

5.3.3.2 Operation of the check procedure

The check routine procedure is illustrated in Figure 5-2/Q.920.



SAPI = 63
TEI = 127

FIGURE 5-2/Q.920

Check routine

The ASP shall transmit a message containing the following elements:

a) Message type = Identity check request
b) the TEI value to be checked in the Ai field

Timer T201 shall be started.

If any user equipment has been assigned the TEI value specified in the check message, it shall respond by transmitting a message containing the following elements :

a) Message type = Identity check response
b) the TEI value in the Ai field
c) Reference number Ri

The Identity check response informs the ASP that the specific TEI value is already assigned.

If no Identity check response is received within T201 the request shall be repeated once and T201 restarted. (T201 is defined in section 5.10.5.)

If no response is received after the second Identity check request, the TEI value shall be assumed to be free and assigned to the requesting user.

5.3.4 TEI removal procedure

When the network management entity determines that the removal of a TEI is necessary (for example, on the receipt of multiple Identity check responses with identical values of Ai, but differing values of Ri, or for other reasons), the ASP shall transmit a message containing the following elements :

a) Message type = Identity remove;

b) TEI value which is to be removed in the Ai field; (the value 127 indicates that all user side equipment should remove their TEI; otherwise, the specific TEI should be removed).

Optionally, the ASP may invoke the check routine procedures to verify that the duplication no longer exists.

All user management entities receiving the Identity remove message containing the currently assigned TEI value in the Ai field shall instruct the data link layer entity, using MDL-REMOVE-REQUEST, to discard the TEI value.

5.3.4.1 Action taken by the data link layer entity receiving MDL-REMOVE-REQUEST

A data link layer entity receiving MDL-REMOVE-REQUEST shall :

a) inform layer 3 using the primitive DL-RELEASE-INDICATION;

b) enter the TEI unassigned state.

5.3.5 Formats and codes

5.3.5.1 General

All messages used for TEI assignment procedure are carried in the information field of UI command frames with a SAPI value set to 63 (binary 111 111) and TEI value set to 127 (binary 1111 111).

All messages are of fixed length and have the following structure :

8	7	6	5	4	3	2	1	
Management entity identifier								Octet 1
Reference number								2
								3
Message type								4
Action indicator							1	5

Fields that are not used in a specific message are coded all zeroes.

The coding of each field for the various messages is specified in Table 5-2/Q.920.

5.3.5.2 Management entity identifier

Octet 1 contains the management entity identifier. Its use is for further study.

5.3.5.3 Reference number (Ri)

Octets 2 and 3 contain the reference number (Ri). It is binary coded and, when used, can assume any value between 0 and 16383.

5.3.5.4 Message type

Octet 4 contains the message type. The purpose of the message type is to identify the function of the message being sent.

5.3.5.5 Action indicator (Ai)

Octet 5 is coded as follows :

a) bit 1 is always coded binary 1;

b) bits 2 to 8 contain the action indicator.

The purpose of the action indicator is to identify the concerned TEI values.

5.4 Automatic negotiation of data link parameter values

The automatic negotiation of data link layer parameter values is for further study.

5.5 Procedures for single frame operation

5.5.1 General

The following procedures shall be used to transfer layer 3 information using point-to-point data link connections when in the link connected state. The procedure makes use of TBN frames.

Note - When using these procedures, duplication of information transfer could occur when delays in the order of timer T200 are encountered. Further, loss of information transfer could happen if the state variables are unsynchronized when line errors occur. In these cases no notification to the layer 3 would be made. The use of these procedures should suit their intended application.

A data link layer entity which only implements single frame operation shall :

a) on receipt of DL-ESTABLISH-REQUEST, return a DL-ESTABLISH-INDICATION and enter the single frame established state;

TABLE 5-2/Q.920

Codes for messages concerning TEI

Message name	Management entity identifier	Reference number Ri	Message type	Action indicator Ai
Identity request	0000 1111	0 - 16383	0000 0001	Ai = 127 = Any TEI acceptable Ai = 0 - 126 = Preferred TEI value
Identity assigned	0000 1111	0 - 16383	0000 0010	Ai = 0 - 126 = Assigned TEI value
Identity denied	0000 1111	0 - 16383	0000 0011	Ai = 0 - 127 = Denied TEI value
Identity check request	0000 1111	Not used (coded 0)	0000 0100	Ai = 0 - 126 = TEI value to be checked
Identity check response	0000 1111	0 - 16383	0000 0101	Ai = 0 - 126 = TEI value in use
Identity remove	0000 1111	Not used (coded 0)	0000 0110	Ai = 127 = Request for removal of all TEI values Ai = 0 - 126 - TEI value to be removed

b) on receipt of DL-RELEASE-REQUEST, return a DL-RELEASE-INDICATION and enter the TEI assigned state.

If a PH-DEACTIVATE-INDICATION is received by the data link service entity from the physical layer at any time during these procedures, the data link layer entity shall inform layer 3 by using the primitive DL-RELEASE-INDICATION.

5.5.2 Transmitting TBN command frames

Layer 3 will pass information for transmission to the data link layer entity by means of the primitive DL-DATA-REQUEST.

The data link layer entity shall :

a) set the poll bit N(P) to the current value of the send state variable V(P);

b) pass the frame to the physical layer using the primitive PH-DATA, indicating the priority parameter of the SAPI;

c) start timer T200.

5.5.3 Receiving a TBN command frame

When a data link layer entity receives a TBN command frame with the poll bit N(P) equal to the current value of its final bit state variable V(F), it shall :

a) pass the contents of the information field to layer 3 by means of the primitive DL-DATA-INDICATION;

b) transmit a TBN response with the final bit N(F) set to the current value of the state variable V(F);

c) complement the value of V(F).

When a data link layer entity receives a TBN command frame with the poll bit not equal to the current value of V(F), the frame shall be discarded and a TBN response shall be transmitted with the final bit N(F) set to the current value of the state variable V(F). V(F) shall not be completed.

A data link layer entity receiving a TBN command in the TEI assigned state shall proceed to the single frame established state and shall inform layer 3 by using the DL-ESTABLISH-INDICATION before forwarding the data in the DL-DATA-INDICATION.

Upon receipt of a TBN command frame without an I field, the procedures in this section shall be followed but the DL-DATA-INDICATION shall not be passed to layer 3 entity.

5.5.4 Receiving a TBN response frame

A data link layer entity, on receipt of a TBN response frame with the final bit set to the current value of the poll bit state variable V(P), shall :

a) complement the value of V(P);

b) reset timer T200;

c) set the retransmission count variable to 0.

If the final bit N(F) is not equal to the current value of V(P) and there have been no retransmissions of the TBN command, the data link layer entity shall :

a) complement the value of V(P);

b) retransmit the TBN command frame with the poll bit set to the current value of V(P);

c) restart timer T200;

d) increment the retransmission count variable.

If the final bit N(F) is not equal to the current value of V(P) and there have been re-transmissions of the TBN command, the data link layer entity shall :

- assume correct delivery of the TBN command frame;
- complement the value of V(P);
- reset timer T200;
- set the retransmission count variable to 0.

5.5.5 Waiting acknowledgement

The data link layer entity shall maintain a retransmission count variable which is set to 0 when a new TBN command is transmitted. The counter shall be incremented for each retransmission of the frame; i.e. upon the expiry of T200. When the retransmission count variable reaches N200 (see section 5.10.2) the data link layer entity shall inform the management entity by means of MDL-ERROR INDICATION, and inform layer 3 using the primitive DL-RELEASE-INDICATION.

5.6 Procedures for establishment and release of multiple frame operation

5.6.1 Establishment of multiple frame operation

5.6.1.1 General

These procedures shall be used to establish multiple frame operation between the network and a designated user entity.

The layer 3 will indicate a request for establishment of the multiple frame operation by the use of the DL-ESTABLISH-REQUEST primitive. Re-establishment may be initiated as a result of the data link layer procedures defined in section 5.8. All frame formats other than U frame formats received during the establishment procedures shall be ignored. The treatment of TBN frames received during the establishment of multiple frame operation is for further study.

5.6.1.2 Establishment procedures

A data link layer entity shall indicate a request for the multiple frame operation to be set by transmitting the Set Aysnchronous Balanced Mode (SABM) or Set Asynchronous Balanced Mode Extended (SABME) command. Timer T200 shall then be started (timer T200 is defined in section 5.10.1). All mode setting commands shall be transmitted with the P bit set to 1.

A data link layer entity receiving an SABM/SABME command shall :

- respond with an Unnumbered Acknowledgement (UA) response with the F bit set to the same binary value as the P bit in the received SABM/SABME command;
- set the send state variable V(S), receive state variable V(R) and acknowledge state variable V(A) to 0;
- enter the multiple frame established state and inform the layer 3 using the primitive DL-ESTABLISH-INDICATION;
- reset the retransmission counter.

If the data link layer entity is unable to enter the multiple frame established state, it shall respond to the SABM/SABME command with a DM response with the F bit set to the same binary value as the P bit in the received SABM/SABME command.

Upon reception of the UA response, the originator of the SABM/SABME shall :

- stop timer T200;
- set the send state variable V(S), receive state variable V(R) and acknowledge state variable V(A) to 0;
- enter the multiple frame established state and inform the layer 3 using the primitive DL-ESTABLISH-INDICATION;
- reset the retransmission counter.

Upon reception of a DM response with F bit set to "1" the originator of the SABM/SABME shall indicate this by means of the primitive DL-RELEASE-INDICATION and MDL-ERROR-INDICATION and stop timer T200.

5.6.1.3 Procedure on expiry of timer T200

If timer T200 expires before the UA or DM response is received from the network, the user shall :

- retransmit the SABM/SABME command as above;
- restart timer T200;
- increment the retransmission counter.

After retransmission of the SABM/SABME command N200 times the data link layer entity shall indicate this by means of the primitive DL-RELEASE-INDICATION and MDL-ERROR-INDICATION and enter the TEI assigned state.

The value of N200 is defined in section 5.10.2.

5.6.2 Information transfer

Having either, transmitted the UA response to a received SABM/SABME command, or received the UA response to a transmitted SABM/SABME command, I and S frames shall be transmitted and received according to the procedures described in section 5.7.

If an SABM/SABME command is received while in the multiple frame established state the data link layer entity shall conform to the re-establishment procedure described in section 5.8.

On receipt of a UI command the procedures defined in section 5.2 shall be followed.

5.6.3 Termination of multiple frame operation

5.6.3.1 General

These procedures shall be used to terminate the multiple frame operation between the network and a designated user entity.

A layer 3 entity shall indicate a request for termination of the multiple frame operation by use of the DL-RELEASE-REQUEST primitive.

All frame formats other than U frame formats received during the release procedures shall be ignored.

5.6.3.2 Release procedure

A data link layer entity shall indicate a request for release to be initiated by transmitting the Disconnect (DISC) command with P bit set to 1. Timer T200 shall then be started and the retransmission counter reset.

A data link layer entity receiving a DISC command while in the multiple frame established state shall transmit a UA response with the F bit set to the same binary value as the P bit in received DISC command. A DL-RELEASE-INDICATION shall be passed to the layer 3.

On reception of the UA response (or DM response while in the TEI assigned state) by the originator of the DISC command, timer T200 shall be stopped.

The data link layer entity will now be in the TEI assigned state. The conditions relating to this state are defined in section 5.6.4.

5.6.3.3 Procedure on expiry of timer T200

If timer T200 expires before a response is received, the originator of the DISC command shall :

- retransmit the DISC command as defined in section 5.6.3.2;
- restart timer T200;
- increment the retransmission counter.

If the data link layer entity has not received the correct response as defined in section 5.6.3.2, after N200 retransmissions of the DISC command, the data link layer entity shall indicate this by means of the primitive DL-RELEASE-INDICATION and MDL-ERROR-INDICATION and enter the TEI assigned state.

The value of N200 is defined in section 5.10.2.

5.6.4 TEI assigned state

While in the TEI assigned state :

- the receipt of a DISC command shall result in the transmission of a DM response;
- the receipt of an I or S frame with the P bit set to 1 shall result in the transmission of a DM response with the F bit set to 1 (as defined in section 5.1.1);
- the contents of any received I frame shall be discarded;
- on receipt of an SABM/SABME command, the procedures defined in section 5.6.1 shall be followed;
- on receipt of UI and TBN commands and responses, the procedures defined in sections 5.2 and 5.5 shall be followed;
- all other frame types shall be discarded.

Note - If the user side link layer entity does not support single frame operation, any received TBN frames may be discarded.

5.6.5 Collision of unnumbered commands

Collision situations shall be resolved in the following way :

5.6.5.1 Identical transmitted and received commands

If the transmitted and received U commands (SABM or SABME or DISC) are the same, the data link layer entities shall send the UA response at the earliest possible opportunity. The indicated state shall be entered after receiving the UA response. The data link layer entities shall notify their respective layer 3 entities, by means of the appropriate indication primitive.

5.6.5.2 Different transmitted and received commands

If the transmitted and received U commands (SABM or SABME or DISC) are different, the data link layer entities shall enter the TEI assigned state and issue a DM response at the earliest possible opportunity. The data link layer entities shall notify their respective layer 3 entities by means of the DL-RELEASE-INDICATION primitive.

5.6.5.3 Unsolicited DM response and SABM or DISC command may be received when a DM response is issued by a data link layer entity at the user side, this is typically a terminal applying a protocol procedure according to X.25, to ask for a mode-setting command, a collision between an SABM or DISC command and the unsolicited DM response may occur.

In order to avoid misinterpretation of the DM response received, a data link layer entity shall always send its SABM or DISC command with the P bit set to 1.

The recovery from this collision situation is for further study.

5.7 Procedures for multiple frame operation

The procedures which apply to the transmission of I frames are defined below.

5.7.1 Transmitting I frames

Information received by the data link layer entity by means of a DL-DATA-REQUEST primitive shall be transmitted in an I frame. The control field parameters N(S) and N(R) shall be assigned the values of the send and receive state variables V(S) and V(R) respectively. The value of the send state variable V(S) shall be incremented by 1.

If timer T200 is not running at the instant of transmission of an I frame, it shall be started. If timer T200 expires, the procedures defined in section 5.7.7 shall be followed.

If the send state variable V(S) is equal to V(A) plus k (where k is the maximum number of outstanding I frames - see section 5.10.4), the data link layer entity shall not transmit any new I frames, but may retransmit an I frame as a result of the error recovery procedures.

When the network side or user side is in the <u>receiver busy</u>[*] condition, it may still transmit I frames, provided that its peer is not busy itself. When the network side or user side is in the frame rejection condition, it shall stop transmitting I frames.

5.7.2 <u>Receiving I frames</u>

When a data link layer entity is not in a receiver busy condition and receives an I frame whose send sequence number is equal to the current receive state variable V(R), the data link layer entity shall :

- pass the information field of this frame to the layer 3 using the primitive *DL-DATA-INDICATION*;

- increment by 1 its receive state variable V(R), and act as follows :

5.7.2.1 If the P bit of the received I frame was set to binary "1", the data link layer entity shall transmit an RR response with the F bit set to binary "1" (as defined in section 5.1.1).

5.7.2.2 If the P bit of the received I frame was set to binary "0" and ;

- if no I frame is available for transmission or if an I frame is available for transmission but the peer entity has indicated a receiver busy condition, the data link layer entity shall transmit an RR response with the F bit set to binary "0";

- if an I frame is available for transmission, the data link layer entity shall in all cases (except when the peer entity is busy) transmit the I frame with the value of N(R) set to the current value of V(R) as defined in section 5.7.1.

When the data link layer entity is in a receiver busy condition, it shall process any received I frame according to section 5.7.6.

5.7.3 <u>Receiving acknowledgement</u>

On receipt of a valid I or S frame (RR, RNR or REJ), even in the busy timer recovery or frame rejection condition, the data link layer entity shall treat the N(R) contained in this frame as an acknowledgement for all the I frames it has transmitted with an N(S) up to and including the received N(R)-1. The value of the acknowledge state vairable V(A) shall be set to the value of N(R). The data link layer entity shall reset the timer T200 on receipt of a valid I or S frame with the N(R) higher than V(A) (actually acknowledging some I frames).

If timer T200 has been reset, and if there are outstanding I frames still unacknowledged, the data link layer entity shall restart timer T200. If timer T200 then expires, the data link layer entity shall follow the retransmission procedure as defined in section 5.7.7 with respect to the unacknowledged I frames.

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[*] In the following text in this Recommendation, the term receiver busy refers to the peer-to-peer flow control state in the data link layer.

5.7.4 Receiving reject

On receipt of an REJ frame, the data link layer entity shall set its send state variable V(S) to the value of the N(R) contained in the REJ frame control field. It shall reset timer T200 and clear the timer recovery condition. It shall transmit the corresponding I frame as soon as possible as defined in section 5.7.1.. Transmission shall take account of the following :

1) if the data link layer entity is transmitting a frame when it receives the REJ, it shall complete that transmission before commencing transmission of the requested I frame.

2) if the data link layer entity is not transmitting a frame when the REJ is received, it shall immediately commence transmission of the request I frame.

All outstanding unacknowledged I frames, commencing with the I frame identified in the received REJ command shall be transmitted.

5.7.5 Receiving RNR

After receiving an RNR command or response, if the data link layer entity is not engaged in a mode setting operation it shall set its acknowledge state variable V(A) to the value of N(R) contained in the control field. The following shall then be performed :

- the data link layer entity shall transmit a supervisory command (RR, RNR or REJ) in order to determine if there is any change in the status of the peer entity. The P bit shall be set to binary 1;

- timer T200 shall be started.

The data link layer entity receiving the supervisory frame with P bit set to 1 shall respond with a supervisory response frame (RR, RNR, REJ) with an F bit set to binary 1, to indicate whether or not the busy condition still exists.

Upon receipt of the supervisory response, the data link layer entity shall reset timer T200 and :

- if the response is RR or REJ, the data link layer entity may transmit new I frames or retransmit I frames as defined in section 5.7.1;

- if the response is RNR, the data link layer entity receiving the response shall repeat, possibly after some delay which is implementation dependent, the enquiry of the peer status.

Note 1 - The N(R) in the received supervisory response with F bit set to 1 may be used to update the send state vairable V(S).

Note 2 - Further study is needed on whether the N(R) in a received supervisory RNR command with a P bit set to 1 may be used to update the send state variable V(S).

Note 3 - In order to optimize the procedures, I frames should not be transmitted towards a peer which has indicated a busy condition with RNR.

If the timer T200 runs out before a status response/command is received, the enquiry process above is repeated with the exception that the re-transmission count variable is incremented rather than being reset. If N200 attempts to get a status response fail (e.g. timer T200 runs out N200 times), the data link layer entity will initiate the re-establishment procedure described in section 5.8. The management entity shall be notified via the MDL-ERROR-INDICATION primitive. (N200 is a system parameter, see 5.10.2).

If a supervisory command (RR, RNR or REJ) is received during the inquiry process, the data link layer entity shall reset timer T200 and;

- if the command is the RR or REJ command, the busy condition is cleared and the data link layer entity may transmit new I frames or re-transmit I frames as specified in sections 5.7.1 or 5.7.4;

- if the command is an RNR command, the busy condition still exists. The data link layer entity will stop timer T200 and reply with an appropriate response frame. The inquiry of the peer status shall be repeated possibly after some delay which is implemented dependent.

Should the received S command contain the Poll bit set to "1", the appropriate response frame with the Final bit set to "1" must be transmitted before the data link layer entity can action the received frame.

5.7.6 Data link layer receiver busy condition

When the data link layer entity enters a receiver busy condition it shall transmit an RNR response at the earliest opportunity. An RNR command may be transmitted instead of RNR response to indicate the busy condition and simultaneously poll the status of peer entity.

All received I frames with the Poll bit set to binary "0" may be discarded, after updating the receive state variable V(R) and acknowledge state variable V(A).

All received I frames with the Poll bit set to binary "1" may be descarded, after updating the acknowledge state variable V(A). However, an RNR response frame with the Final bit set to binary "1" shall be transmitted.

To indicate a clearance of the receiver busy condition, the data link layer entity shall transmit an RR or REJ frame with N(R) set to the current receive state variable V(R).

The busy condition may also be cleared by the transmission of an SABM/SABME command.

5.7.7 Waiting acknowledgement

The data link layer entity shall maintain an internal retransmission count variable which is set to 0 when the data link layer entity transmits or receives a UA response, an RNR response, or when the data link layer entity receives a valid I or S frame with the N(R) higher than the last received N(R) (that is, acknowledging outstanding I frames).

If timer T200 expires the data link layer entity shall :

- enter the timer recovery condition;
- add one to its retransmission count variable;
- set an internal variable "X" to the current value of its send state variable V(S).

The data link layer entity shall then :

- restart timer T200;
- set its send state variable V(S) to V(A), and retransmit the corresponding I frame with the P bit set to binary "1"; or
- transmit an appropriate supervisory command with the P bit set to binary "1"; or
- retransmit the last transmitted I frame (V(S)-1) with the P bit set to binary "1".

The timer recovery condition is cleared when the data link layer entity receives a valid S frame response with the F bit set to binary "1" and may be cleared by receiving an I or S frame acknowledging all outstanding I frames.

If the received frame N(R) is within the range from its current send state variable V(S) to "X" inclusive, it shall set its send state variable V(S) to the value of the received N(R).

If, while in the timer recovery condition, the data link layer entity receives a valid supervisory frame with the F bit set to binary "O" and with an N(R) within the range from its current send state variable V(S) to "X" exclusive, it shall not clear the timer recovery condition. The value of the received N(R) shall be used to update the send state variable V(S) and acknowledge state variable V(A).

If the retransmission count variable is equal to N2, the data link layer entity shall initiate a re-establishment procedure as defined in section 5.8 and indicate this by means of the primitive MDL-ERROR-INDICATION to the management entity. (N200 is a system parameter, see section 5.10.2.)

5.8 Re-establishment of multiple frame operation

5.8.1 Criteria for re-establishment

The procedures for re-establishing the multiple frame operation are defined in this section and are initiated by the receipt of the DL-ESTABLISH-REQUEST from the layer 3 in the normal state or by the following conditions :

- the receipt of frame with procedure errors as defined in section 5.9.4;
- the receipt, while in the multiple frame established state of an unsolicited DM response or FRMR response;

- the receipt, while in the multiple frame established state of a UA response or other unsolicited response with the F bit set to binary "1";

- N200 retransmission failures while in the multiple frame established state.

5.8.2 Procedures

5.8.2.1 Under normal conditions, the procedures defined in section 5.6.1 shall be used to re-establish multiple frame operation.

5.8.2.2 Under certain conditions listed in section 5.8.1, either side may request re-establishment of the link by transmitting an FRMR response. The data link layer entity detecting a receive sequence number error may re-establish the multiple frame operation by immediate transmission of a SABM/SABME command.

After transmitting an FRMR response the data link layer entity shall enter the frame rejection condition : the frame rejection condition is cleared when the data link layer entity receives an SABM/SABME or DISC command.

Any other command received while in the frame rejection condition shall cause the data link layer entity to retransmit the FRMR response with the same information field as originally transmitted.

After receiving FRMR the data link layer entity shall initiate the re-establishment procedures as defined in section 5.6.1 and indicate this by means of the primitive MDL-ERROR-INDICATION to the management entity.

5.9 Exception condition reporting the recovery

Exception conditions may occur as the result of physical layer errors or data link layer procedural errors.

The error recovery procedures which are available to effect recovery following the detection of an exception condition at the data link layer are defined in this section.

5.9.1 N(S) sequence error

An N(S) sequence exception condition occurs in the receiver when a valid I frame is received which contains an N(S) value which is not equal to the receive state variable V(R) at the receiver. The information field of all I frames whose N(S) does not equal the receive state variable V(R) shall be discarded.

The receiver shall not acknowledge (nor increment its receive state variable) the I frame causing the sequence error, nor any I frames which may follow, until an I frame with the correct N(S) is received.

A data link layer entity which receives one or more I frames having sequence errors but otherwise error-free shall use the control field information contained in N(R) and the P bit to perform link control functions; for example, to receive acknowledgement of previously transmitted I frames and to cause the data link layer entity to respond if the P bit is set to binary "1". Therefore, the retransmitted I frame may contain an N(R) field and P bit that are updated from and therefore different from, the ones contained in the originally transmitted I frame.

The REJ is used to initiate an exception recovery (retransmission) following the detection of an N(S) sequence error.

Only one REJ exception condition from a data link layer entity shall be active at a time on one data link correction.

A data link layer entity receiving a REJ command or response shall initiate sequential transmission (retransmission) of I frames starting with the I frame indicated by the N(R) contained in the REJ frame.

A REJ exception condition is cleared when the requested I frame is received or when an SABM, SABME or DISC is received.

5.9.2 <u>Time-out recovery</u>

If a data link layer entity due to an error, does not receive a single I frame or the last I frame in a sequence of I frames, it will not detect an out-of-sequence exception condition and therefore will not transmit REJ.

The data link layer which transmitted the unacknowledged I frame(s) shall, on the expiry of timer T200, take appropriate recovery action as defined in section 5.7.7 to determine at which I frame retransmission must begin.

5.9.3 <u>Invalid frame</u>

Any frame received with an FCS error or which is invalid (as defined in section 2.10) shall be discarded.

<u>Note</u> - Any additional action, e.g. error rate monitoring to be taken by the data link layer is for further study.

5.9.4 <u>Frame rejection condition</u>

A frame rejection condition shall be established upon the receipt of :

- an error free frame which is unknown as a command or response;

- an invalid frame format;

- an invalid N(R);

  <u>Note</u> - Upon the receipt of an invalid N(R), link re-establishment may be performed rather than establishing a frame rejection condition. Further study is required on which of the alternatives is the preferred method.

- an information field which exceeds the maximum information field length which can be accommodated.

At either side, this frame rejection condition shall be indicated by transmission of an FRMR response for appropriate action, followed by the transmission of an SABM, SABME or DISC command. Rather than establishing a frame rejection condition link re-establishment may be initiated directly at the user side (see section 5.8.2).

Once the frame rejection condition has been established, no additional I frames shall be processed (except for examination of the P bit) until the condition is reset.

The FRMR response may be repeated at each opportunity until recovery is effected.

5.10 List of system parameters

The following system parameters listed below are associated with each individual service access point.

A method of assigning these parameters is defined in section 5.4. Other methods of assigning these parameters may be available, but are not part of this Recommendation.

5.10.1 Timer T200

The default[1] value for timer T200 at the end of which transmission of a frame may be initiated according to the procedures described in sections 5.5 and 5.6 shall be one second.

Note - The proper operation of the procedure requires that timer T200 be greater than the maximum time between transmission of command frames and the reception of their corresponding response or acknowledgement frames.

5.10.2 Maximum number of retransmissions (N200)

The maximum number of retransmissions of a frame (N200) is a system parameter. The default value of N200 shall be 3.

5.10.3 Maximum number of octets in an I field (N1)

The maximum number of octets in an I field (N1) is a system parameter. (See also section 2.5).

- For an SAP supporting signalling, the default value shall be 128 octets (provisional value).

  Note - For applications requiring large signalling messages, a single value greater than 128 (e.g. 260) may be specified.

- For SAPs supporting packet information, the default value shall be 260 octets (provisional value).

Note - If and when other SAP types are defined, the appropriate default values will be included in the Recommendation.

---

[1] The term default implies that the value defined should be used in the absence of any assignment or negotiation of alternative values.

5.10.4 Maximum number of outstanding I frames (k)

The maximum number (k) of sequentially numbered I frames that may be outstanding (i.e. unacknowledged) at any given time is a system parameter which shall not exceed 7.

- For an SAP supporting signalling, the default value shall be 1,

- for SAPs supporting packet information, the default value shall be 7.

For extended mode operation (e.g. satellite links), the permissible maximum number of outstanding I frames may be increased to any value up to 127.

5.10.5 Timer T201

The minimum time between retransmission of the TEI-identity check messages (T201) is a system parameter which shall be set to T200 seconds.

5.10.6 Timer T202

The minimum time between the transmission of TEI-identity request messages is a system parameter (T202) which shall be set to 3xT200 seconds.

Appendix : 1

APPENDIX

1. Introduction

The precedural elements defined in section 5 of Q.920 allow for the supervision of the data link layer resource. This Appendix describes procedures which may be used to provide this supervision function. Procedures for both the single frame operation and the multiple frame operation are described. The use of this function is optional.

2. Link layer supervision in the multiple frame established state

The procedures specified herein propose a solution which is already identified in the HDLC classes of procedures. The connection verification is a service provided by data link layer to layer 3. This implies that layer 3 is informed in case of a failure only. Furthermore, the procedure may be incorporated in the "normal" exchange of information and may become more efficient than a procedure based on the involvement of layer 3.

The procedure specified herein is called STATUS ENQUIRY and is based on S command frames (RR command, RNR command) and a timer T203 and operates in the multiple frame established state as follows :

If there are no frames being exchanged on the data link connection (neither new nor outstanding I frames or no S frames with a P bit set to I etc.), there is no means to detect a faulty data link connection condition or if a TE has been unplugged. Timer T203 represents the maximum time allowed without frames being exchanged.

If timer T203 expires, a supervisory command with a P bit set to 1 is transmitted to start a STATUS ENQUIRY. Such a status enquiry is protected against corruption, making use of the normal timer T200 procedure including retransmission count and N200 attempts.

2.1 Connection verification procedures

2.1.1 Restart of timer T203

Upon receiving a frame timer T203 will be restarted.

2.1.2 Expiry of timer T203

Timer T203 supports a suppervisory mechanism to detect a faulty data link connection condition or if a TE has been unplugged during intervals when there are no outstanding frames in either direction. It represents the maximum time allowed without frames being exchanged on a data link layer connection.

If timer T203 expires, the data link layer entity will act as follows (it should be noted that timer T200 is neither running nor expired) :

1) set the retransmission count variable to 0;

2) set STATUS ENQUIRY;

3) transmit a supervisory command with the P bit set to 1 as follows :

   - if there is not a receiver busy condition (own receiver not busy), transmit an RR command;

   - if there is a receiver busy condition (own receiver busy), transmit an RNR command.

4) start timer T200.

Note - Timer T203 may not be needed at the user side.

3. Link layer supervision in the single frame established state

Link supervision in the single frame established state may be performed as follows. A data link layer entity which detects that no frames have been exchanged on the link for a period of time would send a TBN command frame with a zero length information field. The entity receiving the TBN command would respond with a TBN response. Both transmission and reception of these frames should conform to the procedures defined in section 5.5. The DL-DATA-INDICATION primitive should not be passed to the layer 3, since there is no information field in received TBN frames.

A.217

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Recommendation Q.930 (I.451) - Issue 6

SPECIFICATION OF THE ISDN USER-NETWORK INTERFACE
LAYER 3 PROTOCOL

CONTENTS

(3103)

1. General

This Recommendation specifies the procedures for the establishing, maintaining and clearing of network connections at the ISDN user-network interface. These procedures are defined in terms of messages exchanged over the D-channel of basic and primary rate interface structures and the E-channel of the primary rate interface defined in Recommendation I.412 [1]. The functions and procedures of this protocol, and the relationship with other layers, are described in general terms in Recommendation Q.929 (I.450) [2]. In this Recommendation, all references to the D-channel protocol should be assumed to apply to the E-channel unless otherwise specified.

1.1 Scope of the Recommendation

The procedures currently described in this Recommendation are for the control of circuit switched connections, user-to-user signalling connections, and packet switched connections. The carriage of other message based information flows (telemetry etc.) on the D-channel is a subject for further study and will be included in later versions of this Recommendation.

1.2 Structure of the Recommendation

The remaining sections of this Recommendation are as follows.

Section 2 - Overview of call control

Section 3 - Message functional definitions

Section 4 - Message structure

Section 5 - Call control procedures

Section 6 - Application of circuit-switched call control procedures to terminals operating in a stimulus mode

1.3 Application to interface structures

The layer 3 procedures apply to the interface structures defined in Recommendation I.412 [1]. They use all of the functions and services provided by layer 2 with the exception of the unacknowledged information transfer service which is used only on basic access interface structures to provide point-to-multipoint operation at layer 3.

2. Overview of call control

In this Recommendation the terms "incoming" and "outgoing" are used to describe the call as viewed by the user side of the interface.

2.1 Circuit switched calls

This section provides the definition for states that individual calls may have, and provides overview SDL diagrams for the user and network side of the interface. These definitions do not apply to the state of the interface itself, any attached equipment, the D-channel, or the logical links used for signalling on the D-channel and do not apply to the state of the call reference. They are call states. Because several calls may exist simultaneously at a user-network interface, and each call may be in a different state, the state of the interface itself cannot be unambiguously defined.

The overview SDL diagrams (Figure 2/Q.930 and Figure 3/Q.930) are provided to give an overview of the procedures for a circuit switched call. The diagrams do not show all details and show only some of the messages possible at each state, generally those messages most likely to occur at each state. Similarly, to provide a simple overview, timers and their operation are not in general shown explicitly. Internal requests from the network and user sides are shown where necessary for comprehension, but other internal messages at the user and network sides are not shown. The call reference may vary during a call and is not necessarily held for the duration of a call (e.g. call suspension).

Detailed description of the procedures for call control are given in § 5.1 in terms of the sequence of messages defined in § 3 which are transferred across the user-network interface, and the information processing and actions that take place in terminal and the exchange in the process of call establishment and clearing. Transitions between the states defined in this section are included with the message definitions in § 3. Detailed SDL diagrams for call control of circuit-switched calls are contained in § 5.

Throughout this Recommendation reference to B-channels is made as far as circuit-switched calls are concerned. The application of the call control procedures defined in this Recommendation to other channel types is not excluded. Further study on extending the application to other channels types is needed.

2.1.1 Call states at the user side of the interface

The states which may exist on the user side of the user-network interface are defined in this section.

2.1.1.1 Null (State U0)

No call exists.

2.1.1.2 Call unit (U1)

This state exists for an outgoing call, as a result of user action requesting call establishment.

2.1.1.3 Overlap sending (U2)

This state exists for an outgoing call while the user is sending call set-up information to the network in the overlap mode.

2.1.1.4 Call sent (U3)

This state exists for an outgoing call, of the interface, when the network has acknowledged receipt of complete information required for call establishment, and awaits called terminal response.

2.1.1.5 Call delivered (U4)

This state exists for an outgoing call, when the network has completed processing the call to the point of receiving alerting from the user-network interface indicated by the called address, or an alternate interface specified either by the called user or the network (e.g. inband tones or announcements).

2.1.1.6 Negotiate (U5)

This state exists for an incoming call, while negotiation for a suitable B-channel is in progress.

2.1.1.7 Call received (U7)

This state exists for an incoming call when a response/answer is awaited while alerting by the user.

2.1.1.8 Connect request (U8)

This state exists for an incoming call while awaiting receipt from the network of a connect acknowledgement.

2.1.1.9 Active (U9)

This state exists when a call is in the end-to-end communication mode.

2.1.1.10 Disconnect request (U10)

This state exists in response to a request to disconnect a call, prior to acknowledgement by the network.

2.1.1.11 Disconnect indication (U11)

This state exists when the network has indicated disconnect and the user has not yet indicated release or detach.

2.1.1.12 Detach (U12)

This state exists when the B-channel has been released but the call has not been cleared.

2.1.1.13 Suspend request (U13)

This state exists in response to user action to initiate terminal move procedures locally, prior to acknowledgement by the network.

2.1.1.14 Local suspend (U14)

This state exists in response to a suspend request, following receipt of the acknowledgement of the suspend request by the network.

2.1.1.15 Resume request (U15)

This state exists in response to a request to resume a previously suspended call, prior to acknowledgement by the network.

2.1.1.16 Remote facility request (U18)

This state exists in response to a request from the network for the activation of a facility, prior to user response.

2.1.1.17 Local facility request (U19)

This state exists after a request by the user to the network for the activation of a facility, prior to network response.

2.1.2 Network call states

The call states that may exist on the network side of the user-network interface are defined in this section.

2.1.2.1 Null (State N0)

No call exists.

2.1.2.2 Dial tone sending (N1)

This state exists for an outgoing call when the network sends dial tone prior to the receipt of the first INFO message.

2.1.2.3 Overlap-sending (N2)

This state exists for an outgoing call when the network is awaiting further information from the user before attempting call establishment.

2.1.2.4 Call-sent (N3)

This state exists for an outgoing call after the network has received all the information required to proceed with call establishment.

2.1.2.5 Call-delivered (N4)

This state exists for an outgoing call when the network is aware that compatible user equipment exists at the called user interface which can accept the call.

2.1.2.6 Negotiate (N5)

This state exists for an incoming call when the user and the network are attempting to select a B-channel on which to complete the call.

2.1.2.7 Call-present (N6)

This state exists for an incoming call when the call has been indicated by the network but no user has indicated whether the call can be accepted.

2.1.2.8 Call-received (N7)

This state exists for an incoming call after user equipment has indicated the start of user alerting.

2.1.2.9 Connect request (N8)

This state exists when an incoming call is awaiting a response to a connect message to the user.

2.1.2.10 Active (N9)

This state exists when a call is in the end-to-end communication mode.

2.1.2.11 Disconnect-request (N10)

This state exists after a user has indicated disconnect and the network has not yet cleared the connection.

2.1.2.12 Disconnect-indication (N11)

This state exists when the network has indicated disconnect and the user has not yet indicated disconnect.

2.1.2.13 Detach (N12)

This state exists when the B-channel has been released but the call has not been cleared by either the network or the user.

2.1.2.14 Suspend request (N13)

This state exists when the network has received a suspend request but has not yet sent a response to the user.

2.1.2.15 Local suspend (N14)

This state exists when the network has positively acknowledged a request for call suspension.

2.1.2.16 Resume request (N15)

This state exists when the network has received a resume request but has not yet sent a response to the user.

2.1.2.17 Tone active (N16)

This state exists after a network disconnect request when the option of sending in-band tone is used.

2.1.2.18 Release request (N17)

This state exists when the network has initiated the release of user equipment and is awaiting user acknowledgement.

2.1.2.19 Remote facility request (N18)

This state exists after a request from the network for the activation of a facility, prior to user response.

2.1.2.20 Local facility request (N19)

This state exists after a request from the user for the activation of a facility, prior to the network response.

2.1.3 User side call control overview

See Figure 2/Q.930.

2.1.4 Network side call control overview

See Figure 3/Q.930.

2.1.5 State transition tables, action tables and timers

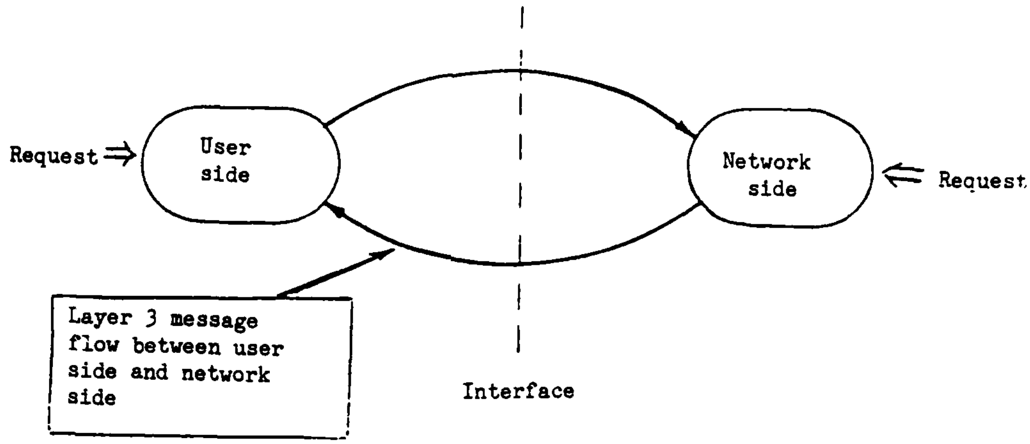
See Figures 4/Q.930 through 7/Q.930.

2.2 Packet switched calls

For further study.

2.3 Other network services

For further study.



Convention for message transmission.

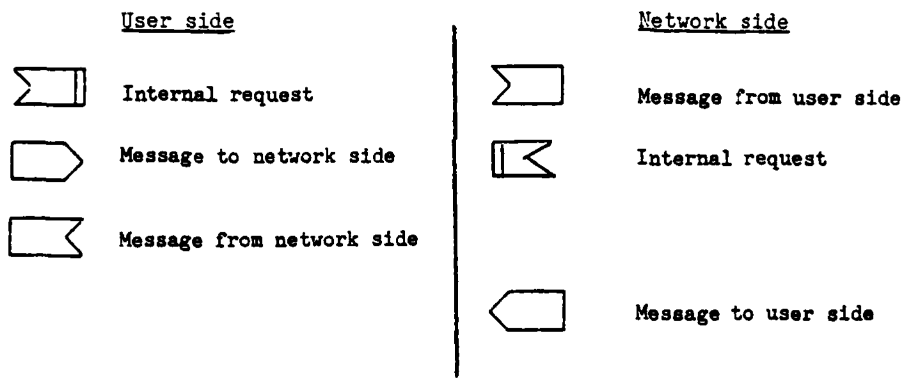


FIGURE 1/Q.930 (I.451)

Key to call control overview

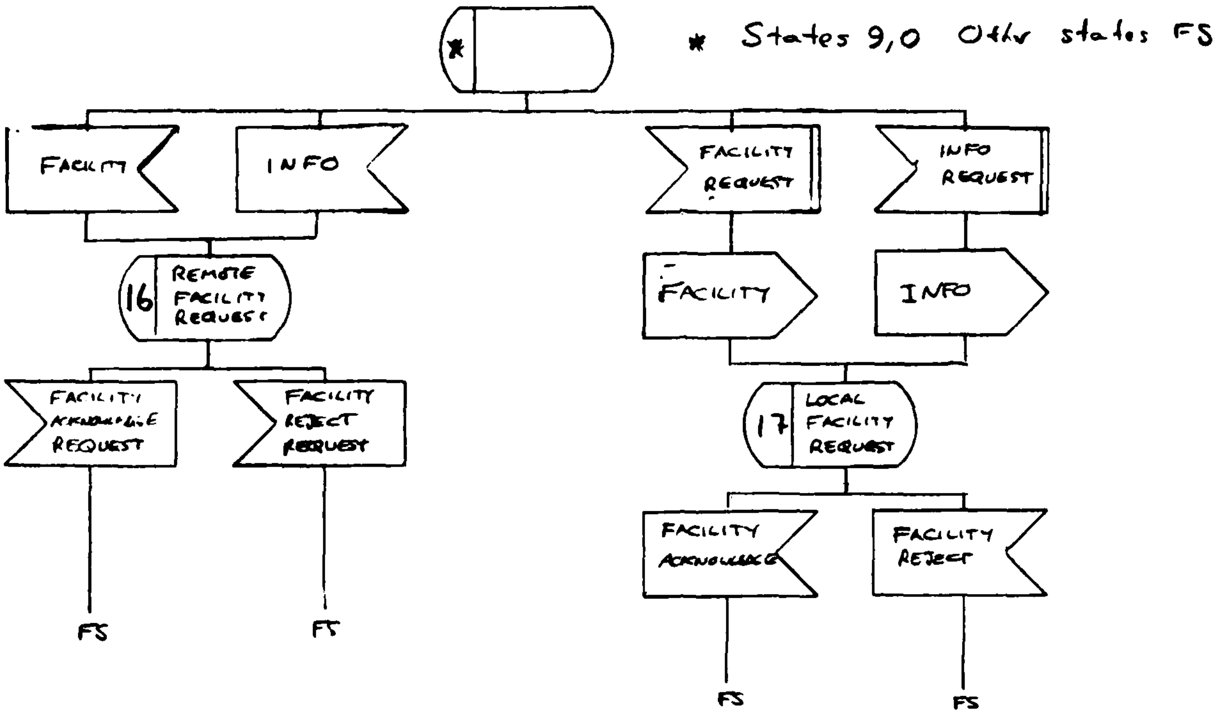


FIGURE 2/Q.930 (5 of 5)

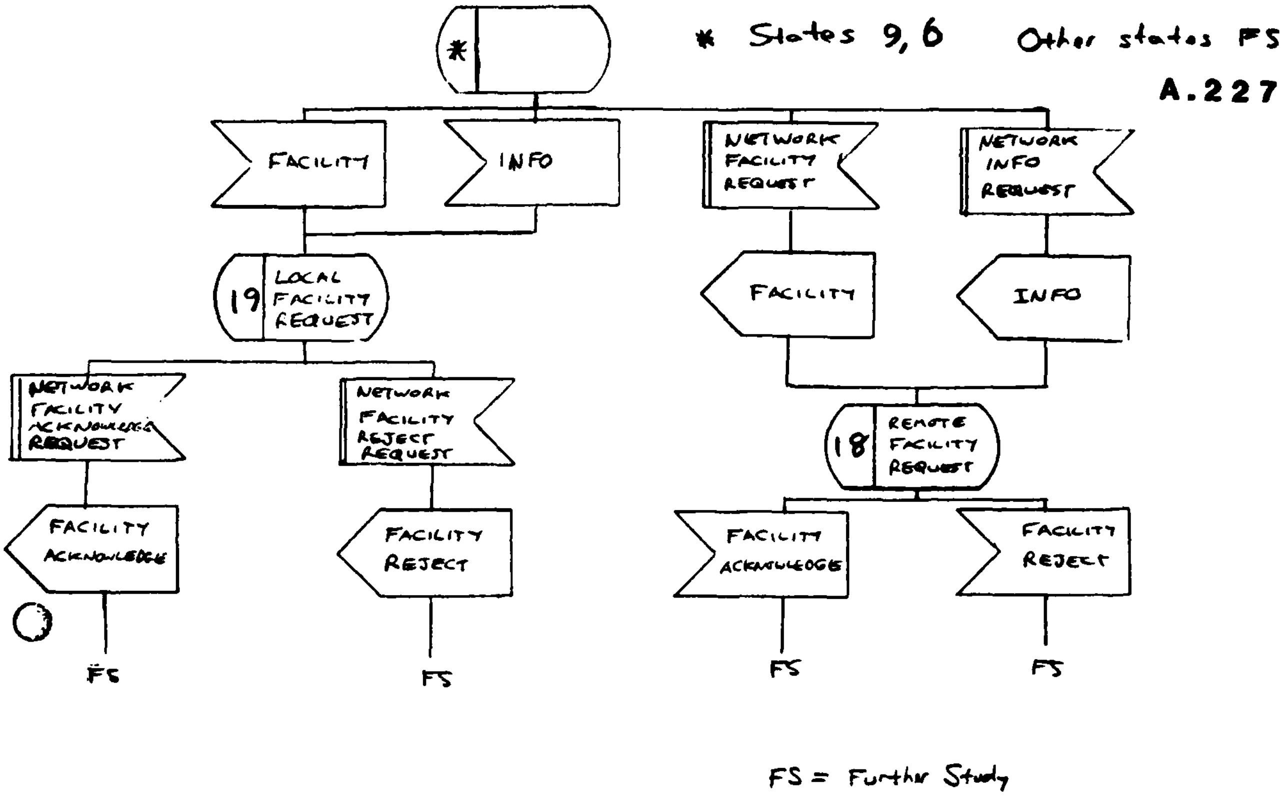
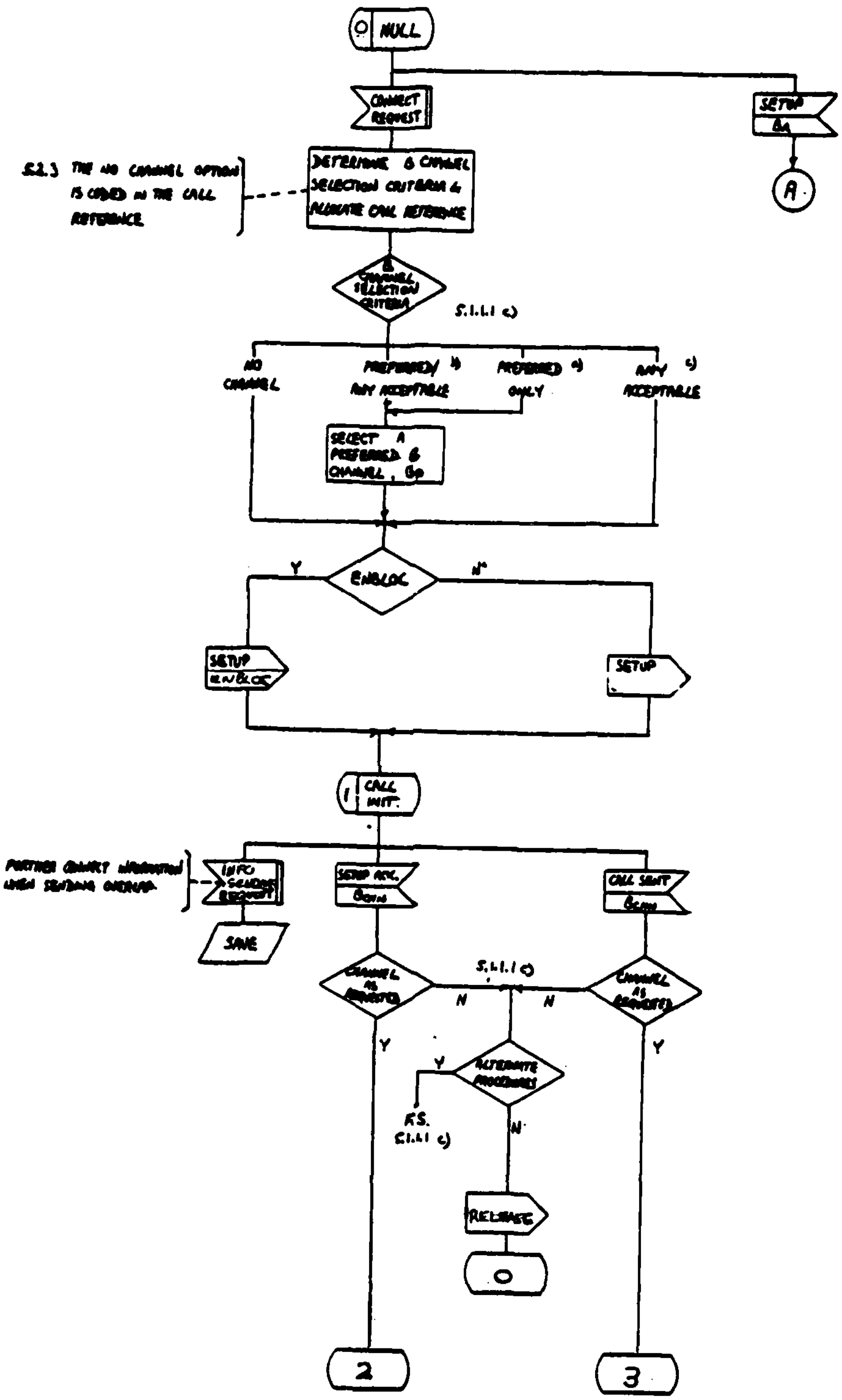
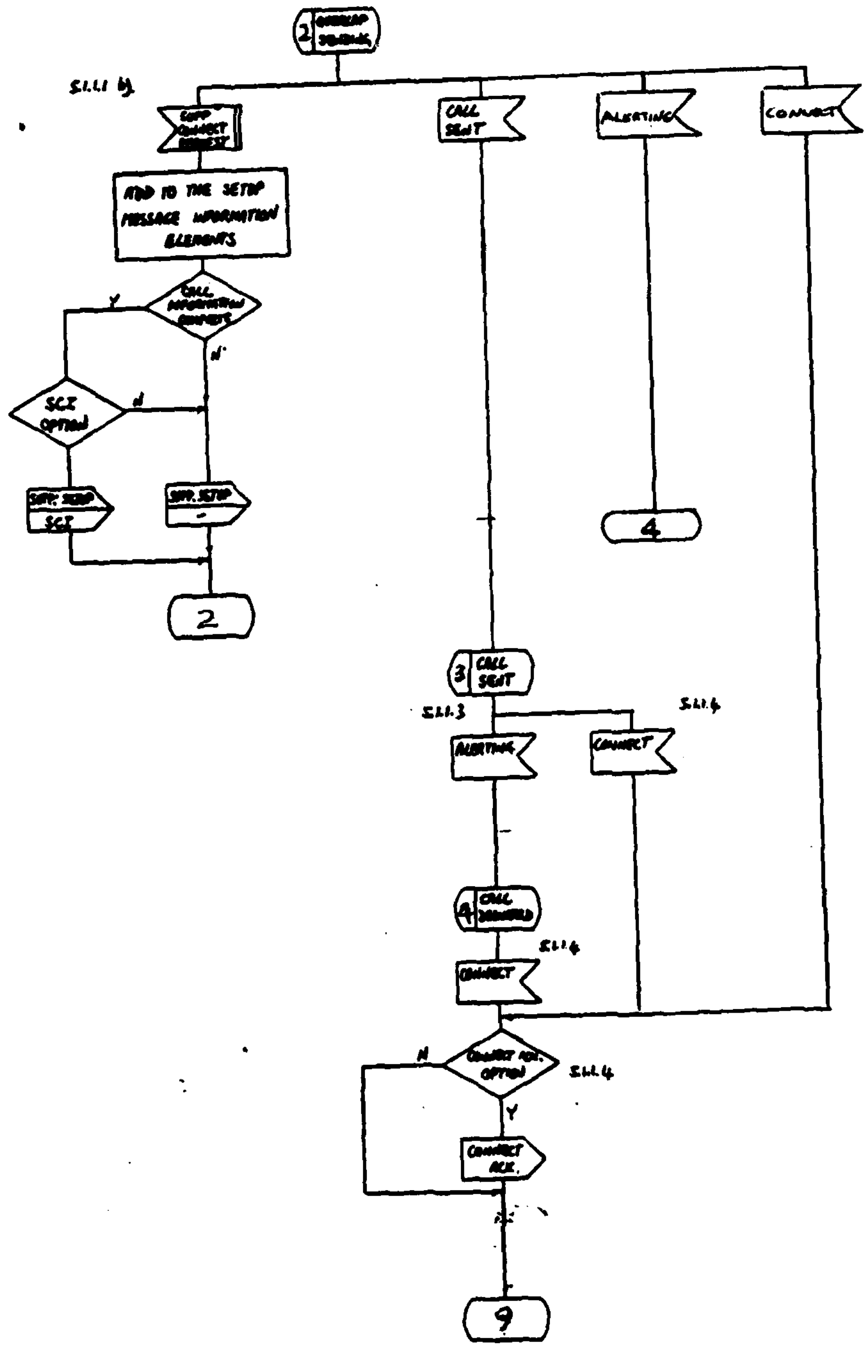


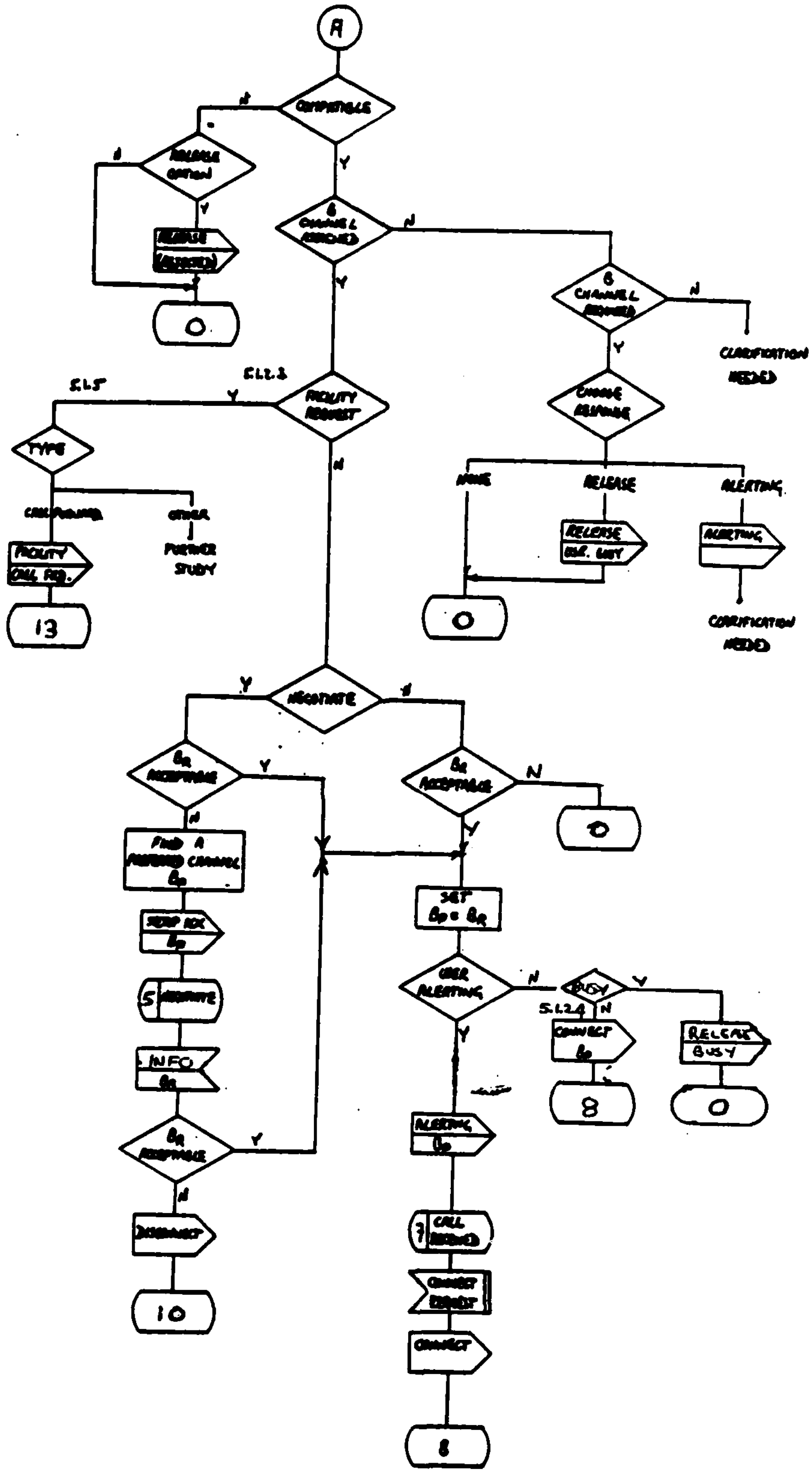
FIGURE 3/Q.930 (SOFS)



USER SIDE

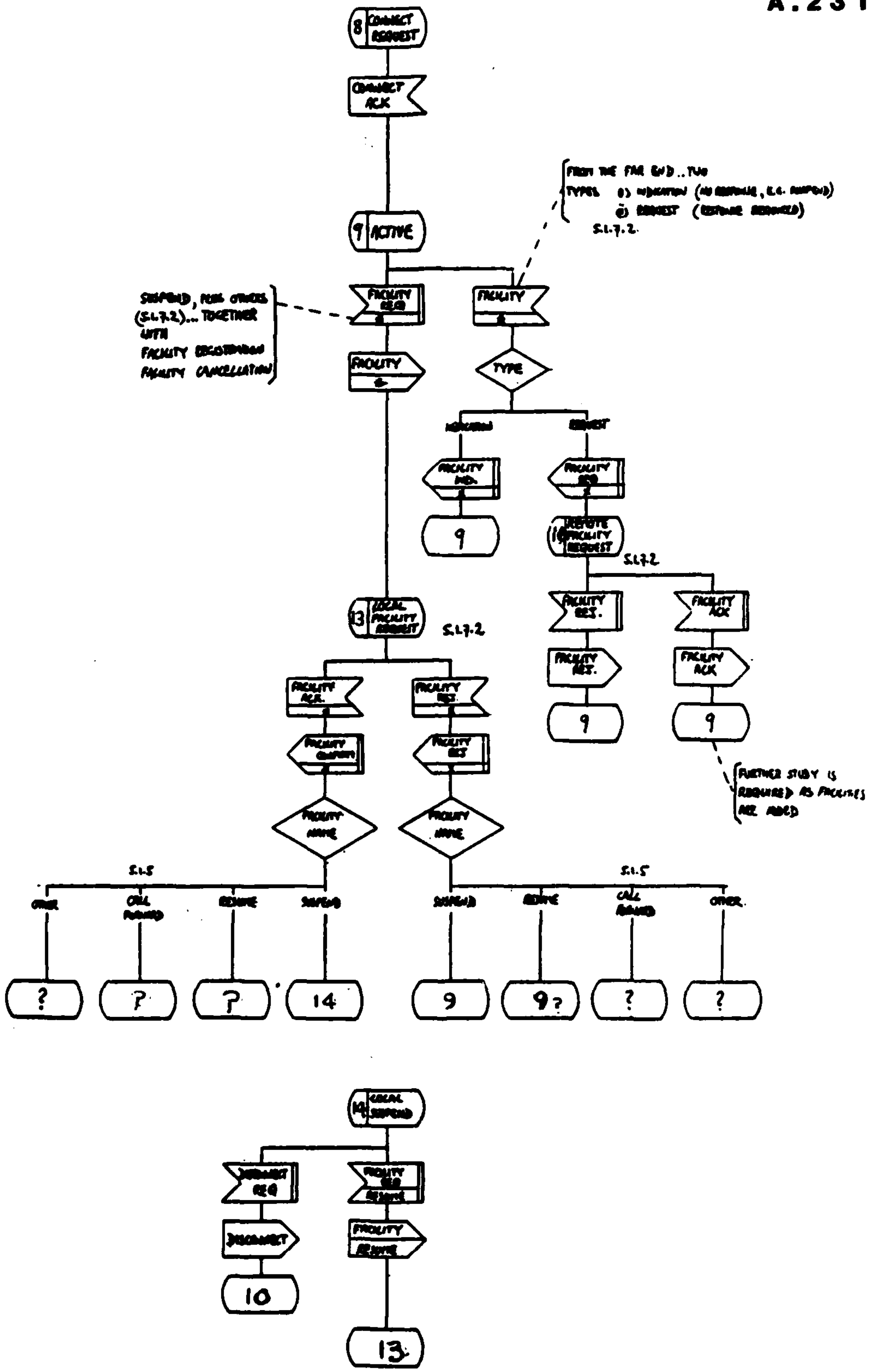
(1 of 5)


2
S.1.1 b)
ADD TO THE SETUP MESSAGE INFORMATION ELEMENTS
Y
N
SCI OPTION
N
SCI
-
2
CALL SENT
ALERTING
CONNECT
4
3
CALL SENT
S.1.1.3
S.1.1.4
ALERTING
CONNECT
S.1.1.4
CONNECT
N
S.1.1.4
Y
CONNECT ACK.
9



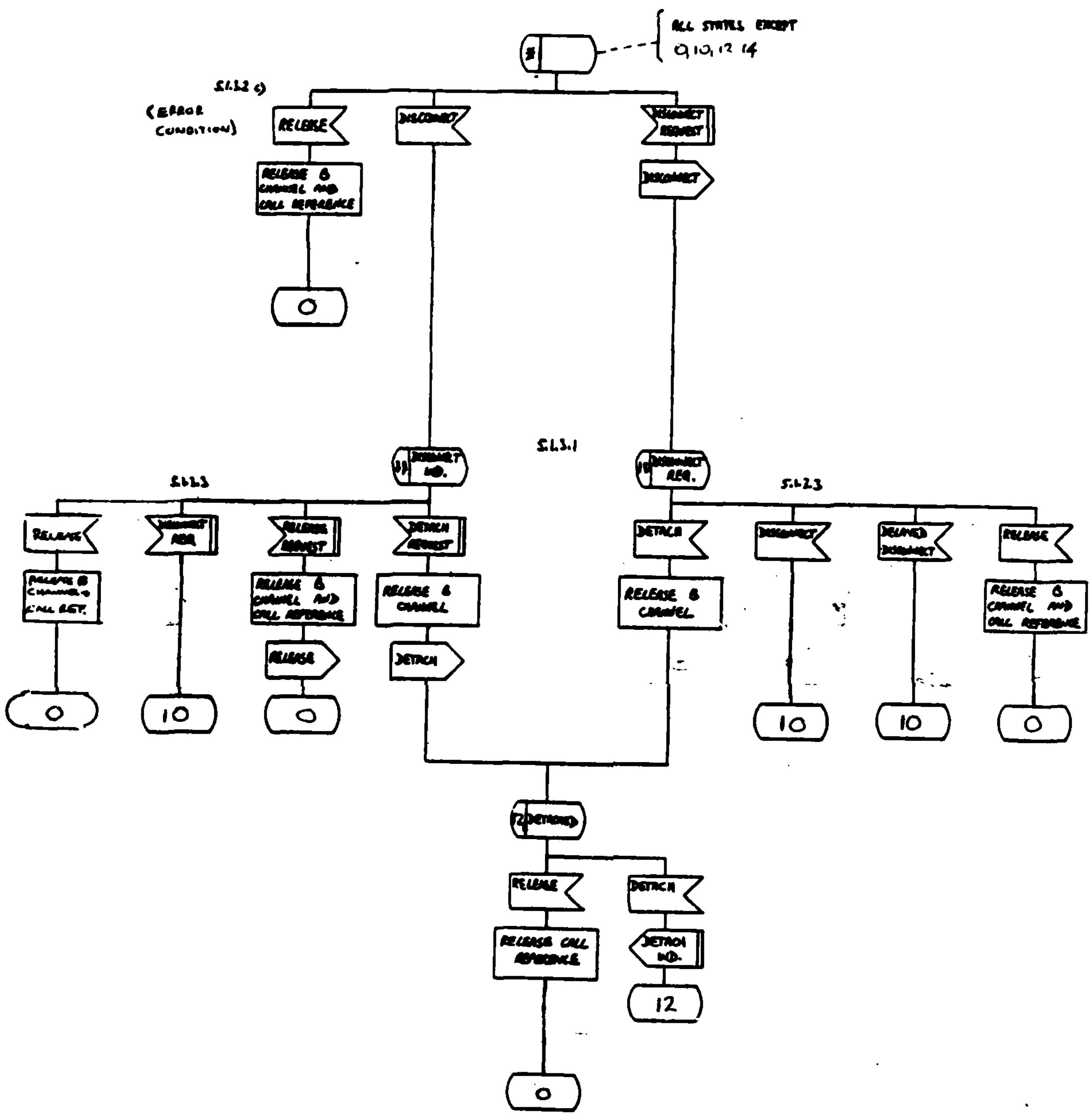
USER SIDE

(3 of 5)



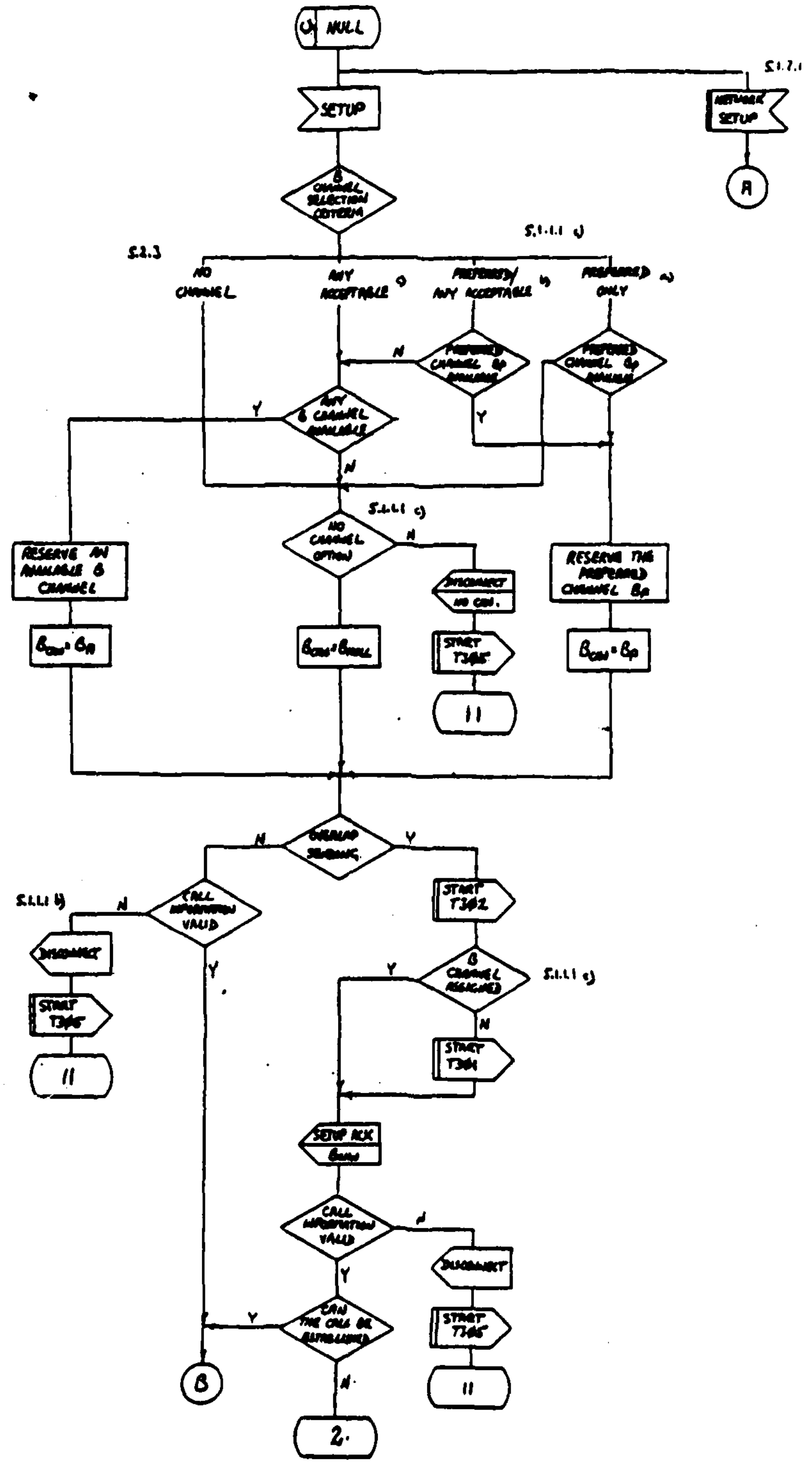
USER SIDE

(6of5)

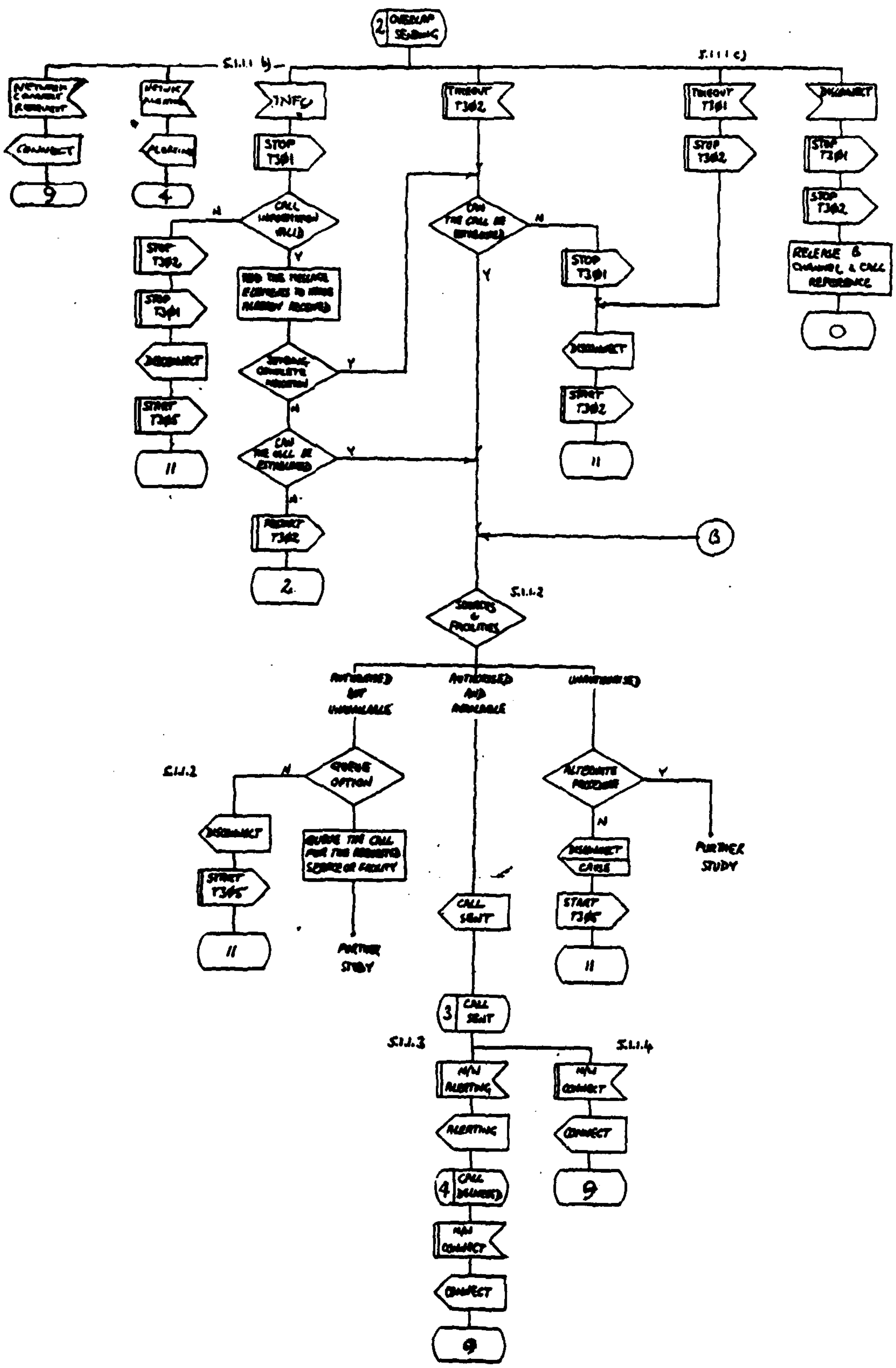


USER SIDE CLEARING : FROM ALL STATES
EXCEPT 0, 10, 12 and 14

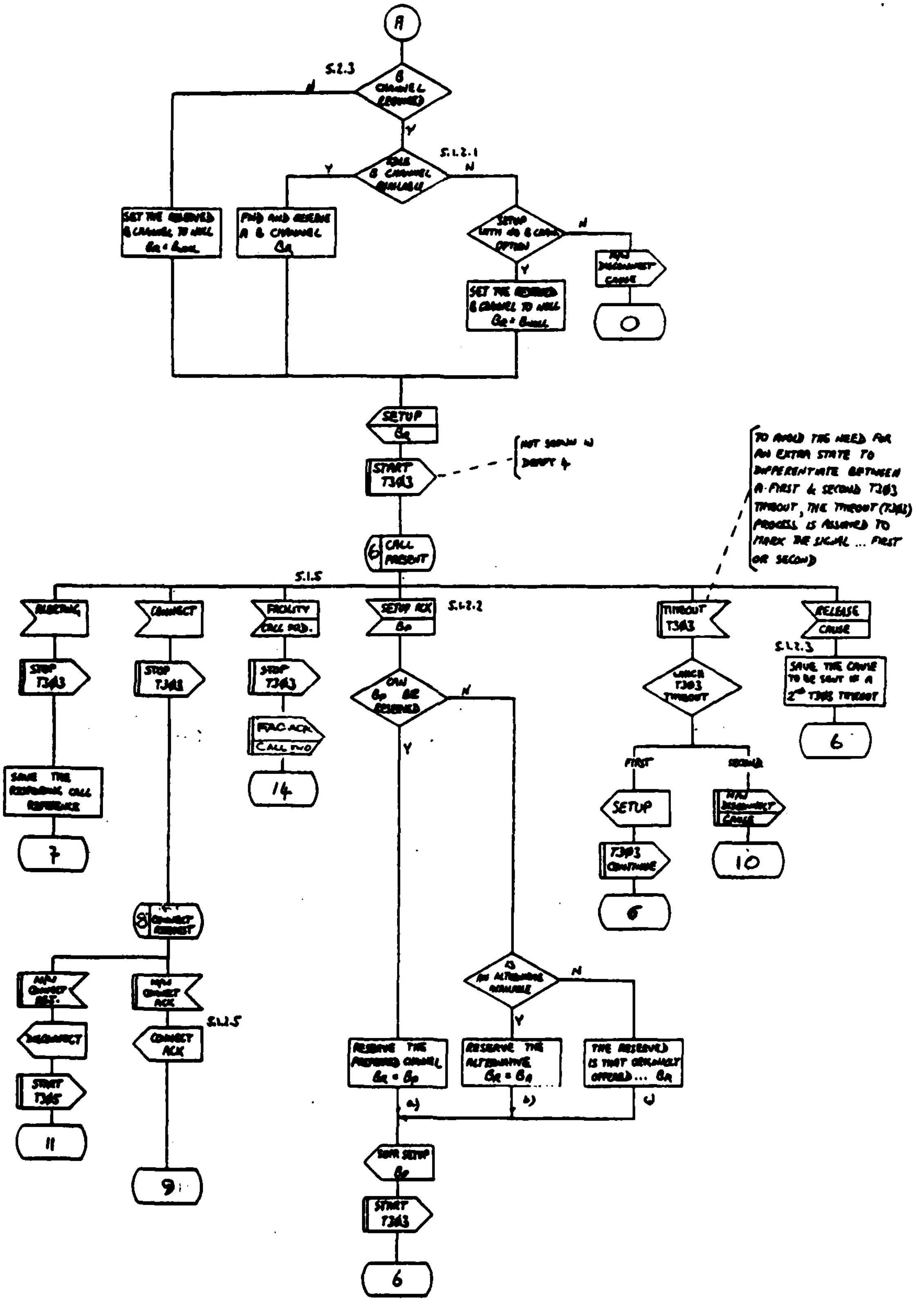
(5 of 5)



NETWORK SIDE DETAIL
(1 of 6)

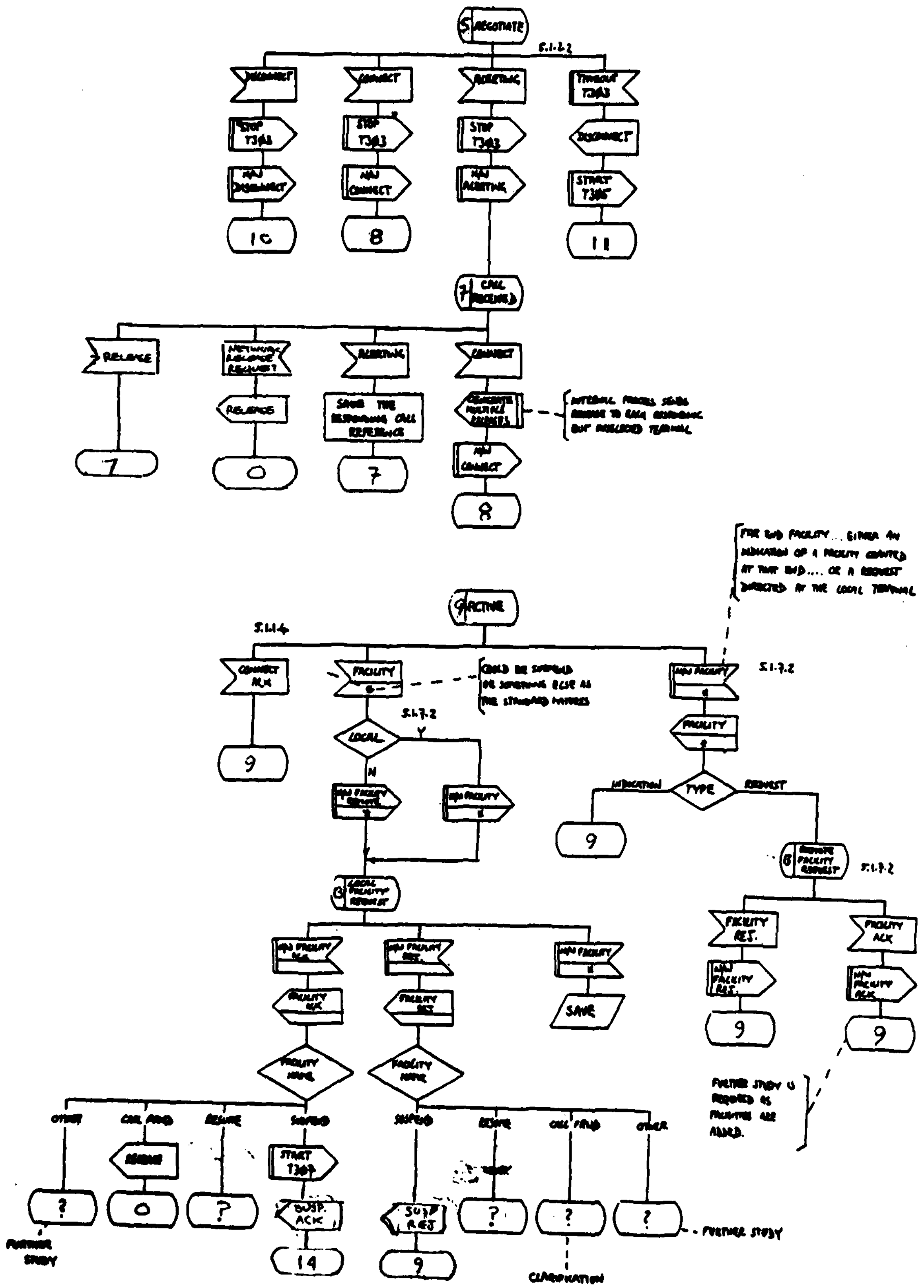


NETWORK SIDE DETAIL
(2 of 6)

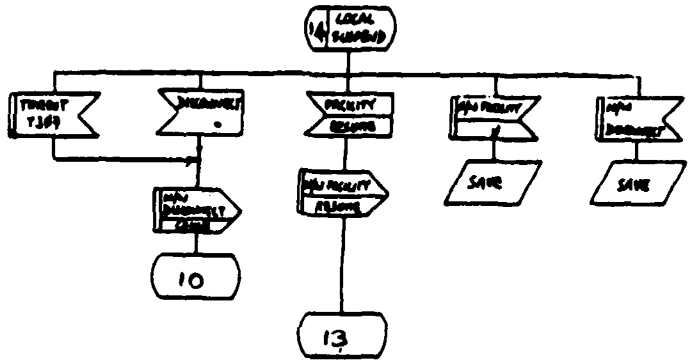


NETWORK SIDE DETAIL

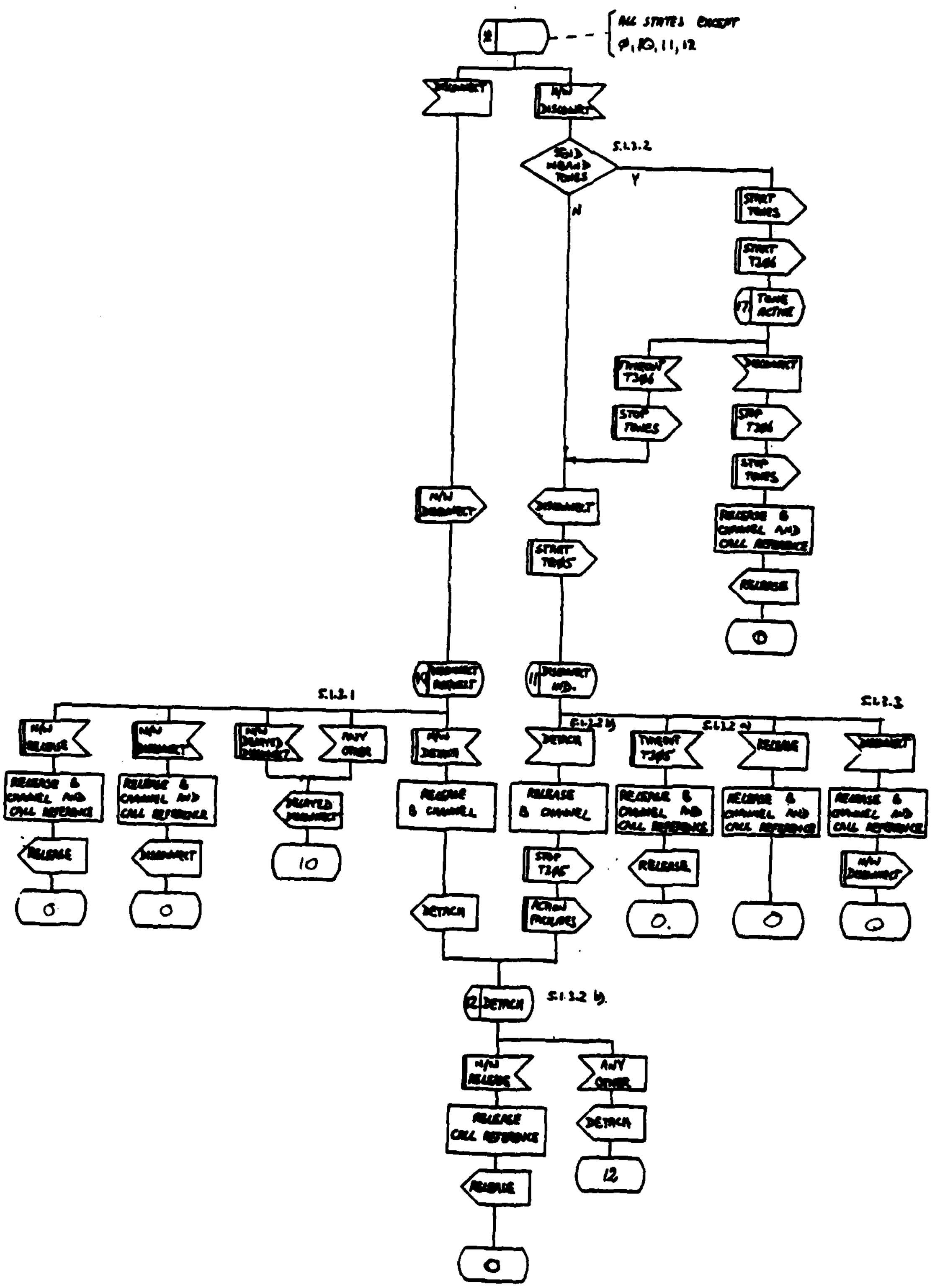
(3 of 6)



NETWORK DETAIL
(4 of 6)



DETAIL
(5 of 6)



NETWORK SIDE CLEARING FROM ALL STATES
EXCEPT 0 & 16 & 6

3. Message functional definitions

3.1 Overview

The message functional definitions are listed in alphabetical order.

Each definition includes :

a) a brief description of the message direction and use;

b) a figure listing the information elements contained in the message. For each information element, the figure indicates :

1) the section of this Recommendation describing the information element;

2) the direction in which it may be sent; i.e., user to network ('u → n') network to user ('n → u') or both;

3) whether inclusion is mandatory ('M') or optional ('O');

4) the length(s), in octets. '?' means the maximum length is undefined.

The information elements are listed in order of appearance in the message. The relative order of information elements is the same for all message types.

Note - All messages may contain network-specific information elements and these have not been included in any of the figures in section 3.

c) further explanatory notes, as necessary.

3.2 Messages for circuit-mode connections

Figure 3-1/Q.930 summarizes the messages and their contents.

3.2.1 ALERTing

This message is sent by the called user to the network, and by the network to the calling user, to indicate that called user alerting has been initiated.

This message is sent by called stimulus terminals to indicate that it has received the SETUP message, (see Figure 3-2/Q.930).

Message type : ALERTing
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
CCITT-standardized facilities	4.5.9	both	O	3 - ?
Network-specific facilities	4.5.19	both	O	3 - ?
Terminal capabilities	4.5.24	n → u	O	3 - ?
Display	4.5.14	n → u	O	3 - ?
Redirecting address	4.5.21	both	O	4 - ?
User-user information	4.5.26	See Note 1	O	3 - Note 2

Note 1 - User-user information may be included for outgoing calls and when an incoming call was offered with the point-to-point procedure. Further study is needed on whether user-user information may be included for incoming calls offered with point-to multipoint procedures.

Note 2 - The maximum length of the user-user information element is network dependent and is either 34 or 130 octets.

FIGURE 3-2/Q.930

ALERTing message content

3.2.2 CANCel REJect

This message is sent by the network to indicate failure of a facility disconnetion (see Figure 3-3/Q.930).

Message type : CANCel REJect
Direction : network to user

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	n → u	M	1
Call reference	4.3	n → u	M	1 - ?
Message type	4.4	n → u	M	1
Cause	4.5.8	n → u	M	3 - ?

Note - The inclusion of other information elements is for further study.

FIGURE 3-3/Q.930

CANCel REJect message content

3.2.3 CONgestion CONtrol

This message is sent by the network to indicate the establishment or termination of flow control on the transmission of USERINFO messages (see Figure 3-4/Q.930).

Note - The ability for the user to send this message to the network is for further study.

Message type : CONgestion CONtrol
Direction : See note

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	See Note	M	1
Call reference	4.3	See Note	M	1 - ?
Message type	4.4	See Note	M	1
Congestion level	4.5.12	See Note	M	1
Cause	4.5.8	See Note	M	3 -
Display	4.5.15	See Note	O	3 - ?

Note - The ability for the user to send this message to the network is for further study.

FIGURE 3-4/Q.930

CONgestion CONtrol message content

3.2.4 Call sent

This message is sent by the network to a user to indicate that requested call establishment has been initiated, and no more call establishment information will be accepted from the user (see Figure 3-5/Q.930).

Message type : CALL SENT
Direction : network to user

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	n → u	M	1
Call reference	4.3	n → u	M	1 - ?
Message type	4.4	n → u	M	1
Channel identification	4.5.10	n → u	M	3 - ?
Display	4.5.15	n → u	O	3x - ?

FIGURE 3-5/Q.930

CALL SENT message content

3.2.5 CANCel ACKnowledge

This message is sent by the network to indicate disconnection of a facility (see Figure 3-6/Q.930).

Message type : CANCellation ACKnowledge
Direction : network to user

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	n → u	M	1
Call reference	4.3	n → u	M	1 - ?
Message type	4.4	n → u	M	1

Note - The inclusion of other information elements is for further study.

FIGURE 3-6/Q.930

CANcel ACKnowledge message content

3.2.6 CONNect

This message is sent by the called user to the network and by the network to the calling user to indicate call acception by the called user (see Figure 3-7/Q.930).

Message type : CONNect
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	FM	1
Call reference	4.3	both	VM	1 - ?
Message type	4.4	both	FM	1
Connected address	4.5.13	both	O	4 - ?
CCITT-standardized facilities	4.5.9	both	O	3 - ?
Network-specific facilities	4.5.19	both	O	3 - ?
Terminal capabilities	4.5.24	n → u	O	3 - ?
Display	4.5.15	n → u	O	3 - ?
Redirecting address	4.5.21	both	O	4 - ?
User-user information	4.5.26	both	O	See Note 2

Note 1 - The inclusion of bearer service and compatibility for negotiation of call characteristics at establishment is for further study.

Note 2 - The maximum length of the user-user information element is network dependent and may be 34 or 130 octets.

FIGURE 3-7/Q.930

CONNect message content

3.2.7 CONNect ACKnowledge

This message is sent by the network to the called user and may be sent by the calling user to the network (see Figure 3-8/Q.930).

Message type : CONNect ACKnowledge
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
Display	4.5.15	n → u	O	3 - ?
Signal	4.5.22	n → u	O	3 - ?

FIGURE 3-8/Q.930

CONNect ACKnowledge message content

3.2.8 DELayed DISConnect

This message is sent by the network to a user to indicate that call clearing is being delayed by the network (see Figure 3-9/Q.930).

Message type : DELayed DISConnect
Direction : network to user

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	n → u	M	1
Call reference	4.3	n → u	M	1 - ?
Message type	4.4	n → u	M	1
Cause	4.5.2	n → u	M	3 - ?
Display	4.5.15	n → u	O	3 - ?

FIGURE 3-9/Q.930

DELayed DISConnect message contents

3.2.9 DETach

This message is sent by either the user or the network to indicate release of the circuit-switched connection while the call reference is retained (see Figure 3-10/Q.930).

Message type : DETach
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
CCITT-standardized facilities	4.5.9	both	O	3 - ?
Network-specific facilities	4.5.19	both	O	3 - ?
Display	4.5.15	n → u	O	3 - ?
User-user information	4.5.26	both	O	3 - Note

Note - 34 or 130, the value being network dependent.

FIGURE 3-10/Q.930

DETach message contents

3.2.10 DISConnect

This message may be sent by either the network or the user to initiate call clearing (see Figure 3-11/Q.930).

Message type : DISConnect
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
Cause	4.5.8	both	M	3 - ?
Display	4.5.15	n → u	O	3 - ?
User-user information	4.5.12	both	O	3 - Note

Note - 34 or 130, the value being network dependent.

FIGURE 3-11/Q.930

DISConnect message contents

3.2.11 FACility

This message is sent by a user to initiate access to a network facility and by the network to a user when access to the facility requires user agreement (see Figure 3-12/Q.930).

Message type : FACility
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
Origination address	4.5.20	both	O	4 - ?
CCITT-standardized facilities	4.5.9	both	See Note 1	3 - ?
Network-specific facilities	4.5.19	both	See Note 1	3 - ?
Display	4.5.15	n → u	O	3 - ?

Note 1 - Either the CCITT-standardized facilities or network-specific facilities information element must be present.

Note 2 - The inclusion of other information elements is for further study.

FIGURE 3-12/Q.930

FACility message content

3.2.12 FACility ACKnowledge

This message is sent by the network to indicate attachment of a requested facility to a call, and by a user to indicate agreement to attachment of a network facility to a call (see Figure 3-13/Q.930).

Message type : FACility ACKnowledge
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
Display	4.5.15	n → u	O	3 - ?

Note - The inclusion of other information elements is for further study.

FIGURE 3-13/Q.930

FACility ACKnowledge message content

3.2.13 FACility CANCel

This message is sent by a user to indicate disconnection of a facility (see Figure 3-14/Q.930).

Message type : FACility CANCel
Direction : user to network

Information element	Reference	Dire[illegible]	[illegible]	[illegible]
Protocol discriminator	4.2	[illegible]	[illegible]	[illegible]
Call reference	4.3	[illegible]	[illegible]	[illegible]
Message type	4.4	[illegible]	[illegible]	[illegible]
CCITT-standardized facilities	4.5.9	[illegible]	[illegible]	[illegible]
Network-specific facilities	4.5.19	[illegible]	[illegible]	[illegible]

Note 1 - Either the CCITT-standardized facilities or [illegible] information element must be present.

Note 2 - The inclusion of other information elements is for further study

FIGURE 3-14/Q.930

FACility CANCel message content

3.2.14 FACility REGister

This message is sent by a user to initiate registration to a network facility, and by the network to a user when registration requires user agreement (see Figure 3-15/Q.930).

Message type : FACility REGister
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message Type	4.4	both	M	1
CCITT-standardized facilities	4.5.9	both	See Note 1	3 - ?
Network-specific facilities	4.5.19	both	See Note 1	3 - ?

Note 1 - Either the CCITT-standardized facilities or the network-specific facilities information element must be present.

Note 2 - The inclusion of other information elements is for further study.

FIGURE 3-15/Q.930

FACility REGister message contents

3.2.15 FACility REJect

This message is sent from the network, or a user, to indicate failure of a facility request (see Figure 3-16/Q.930).

Message type : FACility REJect
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
Cause	4.5.8	both	M	3 - ?
Display		n → u	O	3 - ?

Note - The inclusion of other information elements is for further study.

FIGURE 3-16/Q.930

FACility REJect message content

3.2.16 INFOrmation

This message is sent from the user to the network, or from the network to the user, to provide additional information. It may be used to provide information for call establishment (e.g. direct-dialling-in (DDI)), identify channels in channel negotiation, and to request and provide status on facilities. (see Figure 3-17/Q.930).

Message type : INFOrmation
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
Channel identification	4.5.10	both	O	3 - ?
Destination address	4.5.14	both	O	4 - ?
Transit network selection	4.5.25	u → n	O	3 - ?
CCITT-standardized facilities	4.5.9	u → n	O	3 - ?
Network-specific facilities	4.5.19	u → n	O	3 - ?
Display	4.5.15	n → u	O	3 - ?
Keypad	4.5.16	u → n	O	3 - ?
Keypad echo	4.5.17	n → u	O	3 - ?
Signal	4.5.22	n → u	O	3 - ?
User-user information	4.5.26	u → n	O	3 - Note 2

Note 1 - The need to include the compatibility information element is for further study.

Note 2 - The maximum length of the user-user information element is network dependent and may be 34 or 130 octets.

FIGURE 3-17/Q.930

INFOrmation message content

3.2.17 REGister ACKnowledge

This message is sent by the network to confirm a user facility registration and by a user to indicate agreement with a facility registration when required (see Figure 3-18/Q.930).

Message type : REGister ACKnowledge
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
Display	4.5.15	n → u	O	3 - ?

Note - The inclusion of other information elements is for further study.

FIGURE 3-18/Q.930

REGister ACKnowledge message content

3.2.18 REGister REJect

This message is sent by the network to indicate failure of a registration requested by a user, and is sent by a user to indicate refusal of the attachment of a facility (see Figure 3-19/Q.930).

Message type : REGister REJect
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
Cause	4.5.8	both	M	3 - ?
Display	4.5.15	n → u	O	3 - ?

Note - The inclusion of other information elements is for further study.

FIGURE 3-19/Q.930

REGister REJect message content

3.2.19 RELease

This message is sent, from either the user or the network, to complete call clearing (see Figure 3-20/Q.930).

Message type : RELease
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
Cause	4.5.8	both	M	3 - ?
CCITT-standardized facilities	4.5.9	both	O	3 - ?
Network-specific facilities	4.5.19	both	O	3 - ?
Terminal capabilities	4.5.24	n → u	O	3 - ?
Display	4.5.15	n → u	O	3 - ?
Signal	4.5.22	n → u	O	3 - ?
User-user information	4.5.26	both	O	3 - Note 1

Note 1 - The maximum length of user-user information element is network dependent and is 34 or 130 octets.

FIGURE 3-20/Q.930

RELease message content

3.2.20 RELease ACKnowledge

This message is sent, from either the user or the network, to indicate the completion of call clearing (see Figure 3-21/Q.930).

Message type : RELease ACKnowledge
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1

Note - The inclusion of other information elements is for further study.

FIGURE 3-21/Q.930

RELease ACKnowledge message content

3.2.21 RESume

This message is sent from the user to the network to request re-establishment of a suspended call (see Figure 3-22/Q.930).

Message type : RESume
Direction : user to network

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	u → n	M	1
Call reference	4.3	u → n	M	1 - ?
Message type	4.4	u → n	M	1
Call identity	4.5.6	u → n	O	3 - ?
Channel identification	4.5.10	u → n	O	3 - ?
Terminal capabilities	4.5.24	u → n	O	3

FIGURE 3-22/Q.930

RESume message content

3.2.22 RESume ACKnowledge

This message is sent by the network to the user to indicate completion of a request for call re-establishment (see Figure 3-23/Q.930).

Message type : RESume ACKnowledge
Direction : network to user

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	n → u	M	1
Call reference	4.3	n → u	M	1 - ?
Message type	4.4	n → u	M	1
Channel identification	4.5.10	n → u	M	3 - ?

FIGURE 3-23/Q.930

RESume ACKnowledge message content

3.2.23 RESume REJect

This message is sent by the network to indicate failure to complete a requested re-establishment of a suspended call (see Figure 3-24/Q.930).

Message type : RESume REJect
Direction : network to user

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	n → u	M	1
Call reference	4.3	n → u	M	1 - ?
Message type	4.4	n → u	M	1
Cause	4.5.8	n → u	M	3 - ?

FIGURE 3-24/Q.930

RESume REJect message content

3.2.24 SETUP

This message is sent, from either the user or the network, to indicate call establishment (see Figure 3-25/Q.930).

Message type : SETUP
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
Bearer service identification	4.5.5	both	M	3 - ?
Channel identification	4.5.10	u - n / n - u	0 / M	3 - ?
CCITT-standardized facilities	4.5.9	both	0	3 - ?
Network-specific facilities	4.5.19	both	0	3 - ?
Terminal capabilities		u → n	0	3
Display	4.5.15	n → u	0	3 - ?
Keypad	4.5.16	u → n	0	3 → ?
Signal	4.5.22	n → u	0	3 → ?
Origination address	4.5.20	both	0	4 - ?
Destination address	4.5.14	both	0	4 - ?
Redirecting address	4.5.21	n → u	0	4 - ?
Transit network selection	4.5.25	u → n	0	3 - ?
Compatibility	4.5.11	both	0	3 - ?
User-user information	4.5.26	both	0	3 - Note 1

Note 1 - The maximum length of user-user information element is network dependent and is 34 or 130 octets.

Note 2 - The bearer service and compatibility information elements may be used to describe a CCITT telecommunications service, if appropriate.

FIGURE 3-25/Q.930

SETUP message content

3.2.25 SETUP ACKnowledge

This message is sent by the network to the calling user, and by the called user (on a primary interface structure) to the network, to indicate call establishment has been initiated but will not proceed until additional information is exchanged (see Figure 3-26/Q.930).

Message type : SETUP ACKnowledge
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
Channel identification	4.5.10	both	M	3 - ?
CCITT-standardized facilities	4.5.9	both	0	3 - ?
Network-specific facilities	4.5.19	both	0	3 - ?
Display	4.5.15	n - u	0	3 - ?
Signal	4.5.22	n - u	0	3 - ?

FIGURE 3-26/Q.930

SETUP ACKnowledge message content

3.2.26 STATUS

This message may be sent from either the user or the network at any time during a call when an unexpected message is received or to report other conditions of the call (see Figure 3-27/Q.930).

Message type : STATUS
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
Cause	4.5.8	both	M	3 - ?
Call state	4.5.7	both	M	3

FIGURE 3-27/Q.930

STATUS message content

3.2.27 SUSPend

This message is sent from the user to request suspension of a call (see Figure 3-28/Q.930).

Message type : SUSPend
Direction : user to network

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	u → n	M	1
Call reference	4.3	u → n	M	1 - ?
Message type	4.4	u → n	M	1
Call identity	4.5.6	u → n	O	3 - ?

FIGURE 3-28/Q.930

SUSPend message content

3.2.28 SUSPend ACKnowledge

This message is sent from the network to the user to indicate completion of a requested suspension of a call (see Figure 3-29/Q.930).

Message type : SUSPend ACKnowledge
Direction : network to user

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	n → u	M	1
Call reference	4.3	n → u	M	1 - ?
Message type	4.4	n → u	M	1
Display	4.5.15	n → u	O	3 - ?

FIGURE 3-29/Q.930

SUSPend ACKnowledge message content

3.2.29 SUSPend REJect

This message is sent from the network to the user to indicate failure of a requested call suspension (see Figure 3-30/Q.930).

Message type : SUSPend REJect
Direction : network to user

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	n → u	M	1
Call reference	4.3	n → u	M	1 - ?
Message type	4.4	n → u	M	1
Cause	4.5.8	n → u	M	3 - ?
Display	4.5.15	n → u	O	3 - ?

FIGURE 3-30/Q.930

SUSPend REJect message content

3.2.30 USER INFOrmation

This message is sent by a user to the network to transmit information to another user, and by the network to a user to deliver information from another user (see Figure 3-31/Q.930).

Message type : USER INFOrmation
Direction : both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 - ?
Message type	4.4	both	M	1
More data indication	4.5.18	both	O	1
Display	4.5.15	n → u	See Note	3 - ?
User-user information	4.5.26	both	See Note	3 - 34

Note - Either display or user-user information element, but not both, must be present.

FIGURE 3-31/Q.930

USER INFOrmation message content

3.3 Messages for other types of connections

Note - Other types of circuit-mode connections include leased connections as well as connections whose establishment/clearing may not occur immediately following the relevant user-to-network signalling. The exact terminology for these other types of connections is for further study by CCITT.

3.3.1 The following messages, defined in section 3.2 are used for temporary user-to-user signalling connections :

a) ALERTing

b) CALL SENT

c) CONGestion CONTrol

d) CONNect

e) CONNect ACKnowledge

f) DISConnect

g) RELease

h) RELease ACKnowledge

i) SETUP

j) STATUS

k) USER INFOrmation

Note - The need for possible changes in the contents of these messages is for further study.

3.3.2 The following messages, defined in section 3.2 are used for permanent user-to-user signalling connections :

a) CONGestion CONTrol

b) STATUS

c) USER INFOrmation

Note - The need for possible changes in the contents of these messages is for further study.

3.3.3 The following messages, defined in section 3.2 are used for the support of Recommendation X.25 packet mode connections via the D-channel :

a) RELease

b) RELease ACKnowledge

c) SETUP

d) SETUP ACKnowledge

e) STATUS

Note - The need for possible changes in the contents of these messages is for further study.

3.3.4 The following messages, defined in section 3.2 are used for support of Recommendation X.25 packet mode connections via the B-channel :

a) ALERTing

b) CALL SENT

c) CONNect

d) CONNect ACKnowledge

e) DETach

f) DISConnect

g) RELease

h) RELease ACKnowledge

i) INFOrmation

j) SETUP

k) STATUS

Note - The need for possible changes in the contents of these messages is for further study.

4 Message structure

The figures and text in this section describe message contents. Within each octet, the bit designated "bit 1" is transmitted first, followed by bits 2, 3, 4, etc. Similarly, the octet shown at the top of each figure is sent first.

4.1 Overview

Within this protocol, every message may consist of the following parts :

a) OSI network layer protocol discriminator;

b) call reference;

c) message type;

d) mandatory information elements, as required;

e) additional information elements, when required.

Elements a), b) and c) are common to all the messages and must always be present, while elements d) and e) are specific to each message type.

This organization is illustrated in the example shown in Figure 4-1/Q.930.

A particular message may contain more information than a particular equipment needs or can understand. All equipment should be able to ignore any extra information, present in a message, which is not required for the proper operation of that equipment. For example, a TE may ignore the originating address if that address is of no interest to the TE when a SETUP is received.

Unless specified otherwise, a particular information element may be present only once in a given message.

A particular information element may be present, but empty. For example, it is allowed to send a destination address information element which is of zero length. This should be interpreted by the receiver as equivalent to that information element being absent. Similarly, an absent information element should be interpreted by the receiver as equivalent to that information element being empty.

8	7	6	5	4	3	2	1	
Protocol discriminator								Octet 1
0	0	0	0	Length of call reference value				2
Call reference value								
0	Message type							
Mandatory and additional information elements as required								

FIGURE 4-1/Q.930

General message organization example

4.2 OSI network layer protocol discriminator

The purpose of the OSI network layer protocol discriminator is to distinguish messages for user-network call control from other messages (to be defined) within this Recommendation. It also distinguishes messages of this Recommendation from those OSI network layer protocol units which are coded to other CCITT Recommendations and other standards.

The OSI network layer protocol discriminator is the first part of every message. The OSI network layer protocol discriminator is coded according to Figure 4-2/Q.930.

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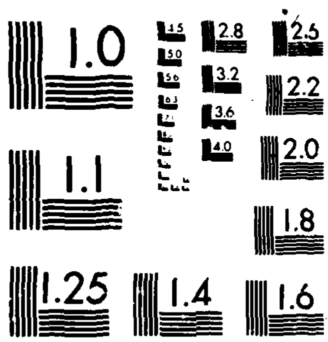

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Note - The need for and the definition of a special protocol discriminator (or another mechanism) for defining layer 3 messages for testing and maintenance is for further study.

8	7	6	5	4	3	2	1	
Q.930 user-network call control messages								
0	0	0	0	1	0	0	0	Octet 1
OSI network-layer protocol discriminator								

The OSI network layer protocol discriminator value is taken from the following table:

8 7 6 5 4 3 2 1	
0 0 0 0 0 0 0 0	reserved.
0 0 0 0 0 0 0 1 through 0 0 0 0 0 1 1 1	reserved for other network layer protocols.
0 0 0 0 1 0 0 0	Q.930 (I.451) user-network call control messages
0 0 0 0 1 0 0 1 through 0 0 0 0 1 1 1 1	reserved for other messages within this Recommendation
0 0 0 1 0 0 0 0 through 0 0 1 1 1 1 1 1	reserved for other network layer protocols, including X.25.
0 1 0 0 0 0 0 0 through 0 1 0 0 1 1 1 1	national use.
0 1 0 1 0 0 0 0 through 1 1 1 1 1 1 1 0	reserved for other network layer protocols, including X.25
1 1 1 1 1 1 1 1	reserved for extension.

FIGURE 4-2/Q.930

OSI network layer protocol discriminator

4.3 Call reference

The purpose of the call reference is to identify the call or facility registration/cancellation request at the local user network interface to which the particular message applies. The call reference does not have end-to-end significance across ISDNs. The call reference is assigned at the beginning of a call and remains fixed for the lifetime of a call (except during suspension). After a call ends, or after successful suspension, the associated call reference value may be reassigned to a later call.

The call reference is the second part of every message. The call reference is coded as shown in Figure 4-3/Q.930. The call reference may be one or more octets long.

Call reference values with octet 2, bit 8 set to "0" are assigned by the user to outgoing calls. These call reference values are unique only for a particular D-channel data link connection. For example, assume two digital telephone TEls are connected in a bus arrangement to an interface at T. Each TEl has one D-channel data link connection with the network, which carries the signalling messages according to this Recommendation. The call designated with the call reference value "0000 1110" on one data link connection is <u>different</u> from the call designated with the same call reference value on the other data link connection.

Call reference values with octet 2, bit 8 set to "1" are assigned by the network to incoming calls. These call reference values are unique for all incoming calls controlled by the same D-channel, regardless of the number of data link connections carrying signalling messages. For example, again assume two digital telephone TEls are connected in a bus arrangement to an interface at T. Each TEl has one D-channel data link connection with the network, which carries the signalling messages according to this Recommendation. The call designated with the call reference value "1000 0000" on one data link connection is the same as the call designated with the same call reference value on the other data link connection.

<u>Note</u> - The dummy call reference is one octet long and is coded "0000 0000". When used, it replaces the call reference (octet 2) and is placed in octet 1. The dummy call reference is used for stimulus operation, and in some other cases such as certain STATUS messages.

8	7	6	5	4	3	2	1	
0	0	0	0	Length of call reference value				Octet 1
0 = out 1 = in	Call reference value							2 etc.

FIGURE 4-3/Q.930

Call reference information element

4.4 Message type

The purpose of the message type is to identify the function of the message being sent.

The message type is the third part of every message. The message type is coded as shown in Figure 4-4/Q.930.

Bit 8 is reserved for possible future use as an extension bit. The coding "1111 1111" is reserved for possible future use as an extension indicator.

8	7	6	5	4	3	2	1	
0	message type							Octet 1

8	7	6	5	4	3	2	1	
0	0	0	-	-	-	-	-	Call establishment messages:
			0	0	0	0	1	- ALERTing.
			0	0	0	1	0	- CALL SENT.
			0	0	1	1	1	- CONNect.
			0	1	1	1	1	- CONNect ACKnowledge.
			0	0	1	0	1	- SETUP.
			0	1	1	0	1	- SETUP ACKnowledge.
0	0	1	-	-	-	-	-	Call informaiton phase messages:
			0	0	1	1	0	- RESume.
			0	1	1	1	0	- RESume ACKnowledge.
			0	0	0	1	0	- RESume REJect.
			0	0	1	0	1	- SUSPend.
			0	1	1	0	1	- SUSPend ACKnowledge.
			0	0	0	0	1	- SUSpend REJect.
			0	0	0	0	0	- USER INFOrmation
0	1	0	-	-	-	-	-	Call disestablishment messages:
			0	0	0	1	0	- DELAYed disconnect.
			0	0	0	0	0	- DETach.
			0	0	1	0	1	- DISConnect.
			0	1	1	0	1	- RELease.
			1	1	0	1	0	- RELease ACKnowledge
0	1	1	-	-	-	-	-	Miscellaneous messages:
			0	1	1	1	0	- CANCel ACKnowledge
			0	0	1	1	1	- CANCel REJect
			0	1	0	0	1	- CONgestion CONtrol
			0	0	0	0	0	- FACility
			0	1	0	0	0	- FACility ACKnowledge
			0	0	1	1	0	- FACility CANCel
			0	0	1	0	0	- FACility REGister
			0	0	1	0	1	- FACility REJect
			0	1	1	0	1	- INFOrmation
			0	1	1	0	0	- REGister ACKnowledge
			0	0	1	0	1	- REGister REJect
			0	0	0	1	1	- STATus

FIGURE 4-4/Q.930

Message types

4.5 Other information elements

4.5.1 The coding of other information elements follows the coding rules described below. These rules are formulated to allow each equipment which processes a message to find information elements important to it, and yet remain ignorant of information elements not important to that equipment.

Two categories of information elements are defined:

a) single octet information elements (see Figure 4-5(a)/Q.930);

b) variable length information elements (see Figure 4-5(b)/Q.930).

For the information elements listed below, the coding of the information element identifier bits is summarized in Figure 4-6/Q.930.

The descriptions of the information elements below are organized in alphabetical order. However, there is a particular order of appearance for each information element in a message. The code values of the information element identifier for the variable length formats are assigned in ascending numerical order, according to the actual order of appearance of each information element in a message. This allows the receiving equipment to detect the presence or absence of a particular information element without scanning through an entire message.

Information elements using the single octet information element identifier may appear at any point in the message.

Where the description of information elements in this Recommendation contains spare bits, these bits are indicated as being coded to "0". In order to allow compatibility with future implementation, messages should not be rejected simply because a spare bit is set to "1".

8	7	6	5	4	3	2	1	
1	Information element identifier			Contents of information element				Octet 1

(a) Single octet information element format.

8	7	6	5	4	3	2	1	
0	Information element identifier							Octet 1
Length of information element (octets)								2
Contents of information element								3
								etc.

(b) Variable length information element format.

FIGURE 4-5/Q.930

Formats of information elements

8 7 6 5 4 3 2 1		Section reference
1 : : : - - - -	Single octet information elements:	
0 0 0 - - - -	reserved	
0 0 1 - - - -	shift	4.5
0 1 0 0 0 0 0	more data	4.5.18
0 1 1 - - - -	congestion level	4.5.12
0 : : : : : : :	Variable length information element:	
0 0 0 0 1 0 0	bearer service identification	4.5.5
0 0 0 1 0 0 0	cause	4.5.8
0 0 0 1 1 0 0	connected address	4.5.13
0 0 1 0 0 0 0	call identity	4.5.6
0 0 1 0 1 0 0	call state	4.5.7
0 0 1 1 0 0 0	channel identification	4.5.10
0 0 1 1 1 0 0	CCITT-standardized facilities	4.5.9
0 1 0 0 0 0 0	network-specific facilities	4.5.19
0 1 0 0 1 0 0	terminal capabilities	4.5.24
0 1 0 1 0 0 0	display	4.5.15
0 1 0 1 1 0 0	keypad	4.5.16
0 1 1 0 0 0 0	keypad echo	4.5.17
0 1 1 0 1 0 0	signal	4.5.22
0 1 1 0 1 1 0	switchhook	4.5.23
1 1 0 1 1 0 0	origination address	4.5.20
1 1 1 0 0 0 0	destination address	4.5.14
1 1 1 0 1 0 0	redirecting address	4.5.21
1 1 1 1 0 0 0	transit network selection	4.5.25
1 1 1 1 1 0 0	compatibility	4.5.11
1 1 1 1 1 1 0	user-user information	4.5.26
1 1 1 1 1 1 1	reserved (escape)	

FIGURE 4-6/Q.930

Information element identifier coding

4.5.2 There are 136 possible information element identifier values using the formatting rules described in section 4.5.1 : 8 from the single octet information element format and 128 from the variable length information element format.

One value in the single octet format is specified for shift operations described below. One other value in both the single octet and variable format is reserved. This leaves 133 information element identifier values available for assignment.

It is possible to expand this structure to eight codesets of 133 information element identifier values each. One common value in the single octet format is employed in each codeset to facilitate shifting from one codeset to another. The contents of this shift item identifies the codeset to be used for the next information element or elements. The codeset in use at any given time is referred to as the "active codeset". By convention, codeset 0 is the initially active codeset.

Two codeset shifting procedures are supported: locking shift and non-locking shift.

Codeset 6 is reserved for information elements specific to the local serving network.

Codeset 7 is reserved for user-specific information elements.

4.5.3 Locking shift procedure

The locking shift procedure employs an information element to indicate the new active codeset. The specified codeset remains active until another locking shift information element is encountered which specifies the use of another codeset. For example, codeset 0 is active at the start of message content analysis. If a locking shift to codeset 7 is encountered, the next information elements will be interpreted according to the information element identifiers assigned in codeset 7, until another shift information element is encountered.

The locking shift information element uses the single octet information element format and coding shown in Figure 4-7/Q.930.

8	7	6	5	4	3	2	1	
1	Shift identifier 0	0	1	0	New codeset identification			Octet 1

"0" in this position indicates locking shift

Codeset identification (bits 3 to 1) :

3 2 1	
0 0 0	codeset 0 (initially active) : Q.930 (I.451) information elements
0 0 1 to 1 0 1	reserved
1 1 0	codeset 6 : information elements specific to the local serving network
1 1 1	codeset 7 : user-specific information elements

FIGURE 4-7/Q.930

Locking shift element

4.5.4 Non-locking shift procedure

The non-locking shift procedure provides a temporary shift to the specified codeset. The non-locking shift procedure uses a single octet information element to indicate the codeset to be used to interpret the next single following information element. After the interpretation of the next single information element, the active codeset is again used for interpreting any following information elements. For example, codeset 0 is active at the beginning of message content analysis. If a non-locking shift to codeset 6 is encountered, only the next information element is interpreted according to the information element identifiers assigned in codeset 6. After this information element is interpreted, codeset 0 will again be used to interpret the following information elements.

The non-locking shift information element uses the single octet information element format and coding shown in Figure 4-8/Q.930.

8	7	6	5	4	3	2	1	
1	0	0 Shift identifier	1	1	Temporary codeset identification			Octet 1

"1" in this position indicates non-locking shift

Note - The codeset identification is coded as shown in Figure 4-7/Q.930.

FIGURE 4-8/Q.930

Non-locking shift element

4.5.5 Bearer service identification

The purpose of the bearer service identification information element is to indicate a requested Recommendation I.200 bearer service.

The coding included in this section is provisional and is a subject for further study. The bearer service identification information element is coded as shown in Figure 4-9a/Q.930. The bearer service identification information element may be repeated in a message to identify multiple services, e.g., in individual transit networks.

No default bearer service may be assumed by the absence of this information element.

<table>
<tr><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td></td></tr>
<tr><td>0</td><td colspan="7">Bearer service identification
0 0 0 1 0 0 0
Information element identifier</td><td>Octet 1</td></tr>
<tr><td colspan="8">Length of the bearer service identification</td><td>2</td></tr>
<tr><td>0/1
Ext</td><td colspan="2">Format coding standard</td><td colspan="5">Access format</td><td>3</td></tr>
<tr><td>1
Ext</td><td colspan="2">0 0
Spare</td><td colspan="5">Multiplier</td><td>3a*</td></tr>
<tr><td>0/1
Ext</td><td colspan="2">Attribute coding standard</td><td>Operation mode</td><td colspan="2">Transfer mode</td><td colspan="2">Transparency</td><td>4*</td></tr>
<tr><td>1
Ext</td><td colspan="2">Symmetry</td><td>0
Spare</td><td colspan="2">Configuration</td><td colspan="2">0 0
Spare</td><td>4a*</td></tr>
<tr><td>0/1
Ext</td><td colspan="2">Rate coding standard</td><td colspan="5">Bearer service rate</td><td>5</td></tr>
<tr><td>1
Ext</td><td colspan="2">0 0
Spare</td><td colspan="5">Multiplier</td><td>5a*</td></tr>
</table>

* This octet may be omitted.

FIGURE 4-9a/Q.930

Bearer service identification information element

Extension bit (octets 3 through 5, bit 8) :

0 access format, attributes or service rate description continues through next octet

1 last octet of access format, attributes or service rate description

Coding standard (octets 3, 4 and 5) :

bits 7 6	
0 0	CCITT standardized in this Recommendation.
0 1	reserved for other international standards.
1 0	national standard.
1 1	standard specific to the network present on the network side of the interface.

Access format (octet 3)

Bits 5 4 3 2 1	Transparent circuit-mode	Non-transparent circuit-mode synchronous	Other synchronous
0 0 0 0 0	-	-	I.451 user-to-user
0 0 0 0 1	0.6 kbit/s	voiceband G.711 A-law a)b)	X.25 protocol/0.6 kbit/s
0 0 0 1 0	1.2 "	voiceband G.711 μ-law a)b)	-
0 0 0 1 1	2.4 "	voiceband G.7zz ADPCM (32 kbit/s) b)	X.25 protocol/2.4 kbit/s
0 0 1 0 0	3.6 "	-	-
0 0 1 0 1	4.8 "	-	X.25 protocol/4.8 kbit/s
0 0 1 1 0	7.2 "	-	-
0 0 1 1 1	8 "	-	-
0 1 0 0 0	9.6 "	speech G.711 A-law a)b)	X.25 protocol/9.6 kbit/s
0 1 0 0 1	14.4 "	speech G.711 μ-law a)b)	-
0 1 0 1 0	16 "	speech G.7zz ADPCM (32 kbit/s) b)	-
0 1 0 1 1	19.2 "	-	-
0 1 1 0 0	32 "	-	-
0 1 1 0 1	-	-	-
0 1 1 1 0	48 "	-	X.25 protocol/48 kbit/s
0 1 1 1 1	56 "	-	-
1 0 0 0 0	64 "	-	X.25 protocol/64 kbit/s
1 0 0 0 1		digital speech G.711 A-law a)b)c)	
1 0 0 1 0		digital speech G.711 μ-law a)b)c)	
1 0 0 1 1	384 kbit/s	digital speech G.7zz ADPCM (32 kbit/s) b)c)	-
1 1 0 0 1	300 bit/s d)	-	-
1 1 0 1 0	200 "	-	-
1 1 0 1 1	150 "	-	-
1 1 1 0 0	110 "	-	-
1 1 1 0 1	75 "	-	-
1 1 1 1 0	50 bit/s d)	-	-
1 1 1 1 1	bearer service rate	-	-

a) - An ISDN will support either A-law or μ-law values. The support of the other coding law is a matter for specific national/network determination. For each particular network, it is recommended that only one coding law be used. But, for certain special national circumstances, a network is allowed to support both coding laws.

b) - The network may subject "speech" to processing suitable for human speech communication (e.g. digital speech interpolation, echo cancellation, very low rate speech coding). For "voiceband" communication, processing not suitable for modern signals will not be performed by the network.

c) - Must only be routed via digital facilities.

d) - These are asynchronous. Other rates in this column are all synchronous.

Multiplier (octet 3a, 5a) :

Bits 1 through 5 are interpreted as a binary integer, n, indicating that the actual bearer service rate or access format is n times the value given in the previous octet. Bit 1 is the least significant bit (2^0).

For transparent operations, the resulting rate is to be considered a transparent aggregate of the bearer service rate or access rate. For non-transparent operations, the result is a bundle of n independent paths at the specified rate.

If octet 3a or 5a is omitted, the value of n is assumed to be 1.

Note - The ability to indicate bundles of independent transparent paths is for further study.

Operation mode (octet 4) :

Bit 5	
0	synchronous operation
1	asynchronous operation

Note - If octet 4 is omitted, synchronous operation is assumed.

Transfer mode (octet 4) :

Bits 4 3	
0 0	circuit mode
1 0	packet-mode

All other values are reserved for further study

Note - If octet 4 is omitted, the transfer mode is assumed to be circuit-mode.

Transparency (octet 4) :

Bits 2 1	
0 0	non-transparent services
1 0	transparent service

All other values are reserved for further study

Note - If octet 4 is omitted, non-transparent services are assumed.

Symmetry (octet 4a) :

Bits 7 6	
0 0	duplex
0 1	this value is reserved for further study
1 0	simplex-outgoing
1 1	simplex incoming

Note - If octet 4a is omitted, the symmetry is assumed to be duplex.

Configuration (octet 4a) :

Bits 4 3	
0 0	point-to-point
1 0	multipoint

All other values are reserved for further study

Note - If octet 4a is omitted, the configuration is assumed to be point-to-point.

Bearer service rate (octet 5) :

Bits 5 4 3 2 1	Circuit-mode rate	Packet-mode throughput
0 0 0 0 1	-	0.6 kbit/s
0 0 0 1 1	-	2.4 kbit/s
0 0 1 0 1	-	4.8 kbit/s
0 0 1 1 1	8 kbit/s	-
0 1 0 0 0	-	9.6 kbit/s
0 1 0 1 0	16 kbit/s	-
0 1 1 0 0	32 kbit/s	-
0 1 1 1 0	-	48 kbit/s
1 0 0 0 0	64 kbit/s	-
1 0 0 1 1	384 kbit/s	-

All other values are reserved for further study.

Note - If octet 5 is omitted, the full rate (e.g. 64 kbit/s for a B-channel) is assumed to apply

8	7	6	5	4	3	2	1	Octet
0	0	0	0	1	0	0	0	Octet 1
0	0	0	0	0	0	0	1	2
1	Coding standard		Access format					3

Defaults : circuit-mode
non-transparent services
point-to-point configuration
duplex connection
synchronous operation

8	7	6	5	4	3	2	1	Octet
0	0	0	0	1	0	0	0	1
0	0	0	0	0	0	1	0	2
1	Coding standard		Access format					3
1	Coding standard		Op	Mode		Transp.		4

Defaults : point-to-point configuration
duplex connection

8	7	6	5	4	3	2	1	Octet
0	0	0	0	1	0	0	0	1
0	0	0	0	0	1	0	0	2
1	Coding standard		Access format					3
0	Coding standard		Op	Mode		Transp.		4
1	Symmetry		0	Configur.		0	0	4a
1	Coding standard		Bearer service rate					5

No default values assumed

← indicates where multiplier may be present

FIGURE 4-9b/Q.930

Examples of bearer service identification

4.5.6 Call identity

The purpose of the call identity information element is to identify the suspended call. The call identity provided by the user is guaranteed by the network to be unique over a domain of interfaces where the call may be resumed. The call identity is assigned at the start of the call suspension, and is available for re-use after the resume procedure has completed successfully.

The call identity information element is coded as shown in Figure 4-1/Q.930.

8	7	6	5	4	3	2	1	
0	0	1	0	1	0	0	0	Octet 1
	Call identity information element identifier							
length of call identity								2
call identity (any pattern allowed)								3 etc.

FIGURE 4.10/Q.930

Call identify information element

4.5.7 Call state

The purpose of the call state information element is to describe the current status of a call.

The call state information element is coded as shown in Figure 4-11/Q.930.

8	7	6	5	4	3	2	1	
0	0	1	1	0	0	0	0	Octet 1
	Call state information element identifier							
length of call state value								2
call state value (See Note)								3 etc.

State No. (Octet 3)	User state	Network state
0	null	null
1	call init	dial tone sending
2	overlap sending	overlap sending
3	call sent	call sent
4	dall delivered	call delivered
5	negotiate	negotiate
6	-	call present
7	call received	call received
8	connect request	connect request
9	active	active
10	disconnect request	disconnect request
11	disconnect indication	disconnect indication
12	detach	detach
13	suspend request	suspend request
14	local suspend	local suspend
15	resume request	resume request
16	-	tone active
17	-	release request
18	remote facility request	remote facility request
19	local facility request	local facility request

Note - The call state value is the binary coding of the state number, with bit 1 as the least significant bit (2^0).

FIGURE 4-11/Q.930

Call state information element

4.5.8 Cause

The purpose of the cause information element is to describe the reason for generating certain messages, and to provide diagnostic information in the event of procedural errors.

The cause information element is coded as shown in Figure 4-2/Q.930. Diagnostic information is not available for every cause. When available the coding of the diagnostic(s) is the same as for the corresponding information element in section 4 (some code formats are for further study).

The cause information element and diagnostic may be repeated in a message, e.g. to report multiple errors associated with a single call.

8	7	6	5	4	3	2	1	
0	0	0	0	1	0	0	0	Octet 1
	Cause information element identifier							
Length of cause information element								2
Ext	Cause value							3 etc.
Diagnostic(s) (if any)								

FIGURE 4-12/Q.930

Cause information element

Cause value 7654321	Cause	Diagnostics
0000001	invalid call reference value	call ref. value
0000010	message not implemented	message type
0000011	bearer service not implemented	service
0000100	connection type not implemented	
0000101	channel type not implemented	channel type
0000110	identified channel does not exist	channel ID
0000111	call identity does not exist	call identity
0001000	call identity in use	call identity
0001000	overlap sending not allowed	
0001010	no channel available	
0010000	requested facility not implemented	network id, facility
0010001	requested facility not subscribed	network id, facility
0010011	invalid facility parameter	network id, facility
0100000	outgoing calls barred	
0100001	outgoing calls barred within CUG (orig.)	CUG, id.
0100010	incoming calls barred within CUG (dest.)	CUG id, dest. address
0100011	non-existent closed user group	CUG number
0100100	destination address not member of CUG	dest. address, CUG number
0110000	reverse charging not allowed (at orig. end)	
0110001	reverse charging not allowed (at dest. end)	
0110010	reverse charging rejected	
0110011	incompatible destination	dest. address incompatible parameter
0110100	non-existent abbreviated address entry	copy of address element
0110101	destination not obtainable	dest. address
0110110	destination address missing, and direct call not subscribed	
0110111	this call waiting at destination	dest. address
0111000	number changed	dest. address, new dest. address
0111001	out of order	dest. address
0111010	no user responding	dest. address
0111011	user busy	dest. address
0111100	call waiting not subscribed	dest. address
0111101	incoming calls barred	dest. address optional user-specified info.
0111110	call rejected	user-supplied. diagnostic
1000000	degraded service (e.g., excessive error rate)	
1000001	circuit out-of-order	circuit id.
1000010	circuit operational	circuit id.
1010000	transit network out of order	transit network id.
1010001	transit network selection not implemented	
1010010	transit network does not exist	transit network id.
1010011	transit delay range cannot be achieved	min. available transit delay
1010100	throughput range cannot be achieved	max. available throughput
1011000	network failure	dest. address
1011001	network congestion	network id.
1011010	remote user initiated	remote user address remote user-supplied cause info.

FIGURE 4-13/Q.930

Cause information element

Cause value 7 6 5 4 3 2 1	Cause	Diagnostics
1 1 0 0 0 0 0	X.21 DTE controlled-not-ready	dest. address
1 1 0 0 0 0 1	X.21 DTE uncontrolled-not-ready	dest. address
1 1 0 0 0 1 0	PAD clearing	
1 1 0 0 0 1 1	time-out on start of X.25 data	
1 1 0 0 1 0 0	packet size not available	
1 1 0 0 1 0 1	packet window size not available	
1 1 1 0 0 0 0	local procedure error	copy of erroneous message
1 1 1 0 0 0 1	remote procedure error	
1 1 1 0 0 1 0	remote user suspended	user address
1 1 1 0 0 1 1	remote user resumed	user address
1 1 1 1 1 1 1	user INFO discarded locally	copy of first 32 octets of user-user information element

FIGURE 4-13/Q.930

Cause information element
(continuation)

4.5.9 CCITT-standardized facilities

The purpose of the CCITT-standardized facilities information element is to indicate which CCITT-standardized binary facilities are being invoked. "Binary facilities" are those which do not require a parameter. Parameterized facilities are invoked as separate information elements.

The facilities information element is coded as shown in Figure 4-14/Q.930.

The facilities are given in Figure 4.14/Q.930. This figure also identifies which facilities may be invoked on a per-call basis, and which may be invoked to apply continuously to all interface operations after invocation.

8	7	6	5	4	3	2	1	
0	CCITT-standardized facilities 1 1 0 1 0 0 0 information element identifier							Octet 1
Length of CCITT-standardized facilities information								2
CCITT-standardized facilities (See Note 4)								3 etc.

per call	contin-uous	CCITT-stadardized facility invoked when set to "1"
x	x	Delivery of origination address barred.
x	x	Connected address required.
x	x	Supply charging information after end of call.
x		Reverse charging requested.
x	x	Connect outgoing calls when free.
x	x	Reverse charging acceptance (allowed).
x		Call redirection/diversion notification. Note 3
x		Call completion after busy request.
x		Call completion after busy indication.
	x	Origination address required on outgoing calls.
	x	Origination address desired on incoming call.
	x	Destination address required on incoming calls.
	x	Connect incoming calls when free (waiting allowed).
	x	X.25 extended packet sequence numbering (modulo 128)
	x	X.25 flow control parameter negotiation allowed.
	x	X.25 throughput class negotiation allowed.
	x	X.25 packet retransmission (allowed).
	x	X.25 fast select (outgoing) (allowed).
	x	X.25 fast select acceptance allowed.
	FS	X.25 multilink procedure
	x	Local charging prevention
	x	X.25 extended frame sequence numbering

Note 1 - Names used to describe the above facilities are provisional. Final choice of facility name and definition is for further study.

Note 2 - Other facilities are for further study.

Note 3 - Classification of similarities and differences between redirection and diversion is for further study.

Note 4 - The coding of this information element is for urgent further study.

FIGURE 4-14/Q.930

CCITT-standarduzed facilities information element

4.5.10 Channel identification

The purpose of the channel identification information element is to identify a channel or subchannel within the interface(s) controlled by these signalling procedures.

The channel identification information element is coded as shown in Figure 4-15/Q.930. The channel identification information element may be repeated in a message; e.g. to list several acceptable channels during channel negotiation.

8	7	6	5	4	3	2	1	
0	Channel identification information element identifier							
	0	1	1	1	0	0	0	Octet 1
Length of channel identification								2
0/1 Ext	Int id	Int type	0 spare	Pref/Excl	D-ch ind	Info chan selection		3
1 Ext	Symmetry		0	0	0	0	0	3a*
			Spare					
0/1 Ext	Interface identifier							3b*
0/1 Ext	Coding standard		#/Map	Channel type/Map element type				4 (Note 2)
Channel #/Slot map								5 (Note 2)
0/1 Ext	Coding standard		#/Map	Channel type/Map element type				5a*
Sub-channel #/Sub-slot map								5b*
Note 1								

Note 1 - Same formats can be repeated to indicate the sub-unit (e.g. sub-sub-channel) of the unit indicated by the preceding format (e.g. sub-channel).

Note 2 - This information is replaced by "channel selection" in Octet 3, and is omitted, when "Interface type" in Octet 3 is "basic interface".

Note 3 - Octets with * may be omitted.

Note 4 - Existence of sub-channel indication (Octet 5a~) is implicitly indicated by "Length of channel identifier" in Octet 2.

FIGURE 4-15/Q.930

Channel identification information element

Extension bit (Octet 3, 3a, 3b, 4, 5a)

0 : description is extended through the next octet
1 : last octet of the description

Interface identifier present (Octer 3)

0 : Interface implicitly identified (Note)

Note - The interface which includes the D-channel carrying this information element is indicated.

1 : Interface explicitly identified (in Octer 3b)

Interface type (Octet 3)

0 : basic interface
1 : other interface (Note)

Note - Interface type should be identified by the interface identifier.

Preferred/Exclusive (Octet 3)

0 : indicated channel is preferred
1 : exclusive; only the indicated channel is acceptable

D-channel indicator (Octet 3)

0 : no D-channel
1 : D-channel is indicated

Information channel selection (Octet 3)

	Basic interface	Other interface
0 0 :	No channel	No channel
0 1 :	B1 channel	As indicated below
1 0 :	B2 channel	Reserved
1 1 :	Any channel	Any channel

Symmetry (Octet 3a)

0 0 : duplex
0 1 : reserved
1 0 : simplex outgoing (from user to network)
1 1 : simplex incoming (from network to user)

Note - If octet 3a is omitted, the symmetry is assumed to be duplex.

Interface identifier (Octet 3b)

Binary code assigned to the interface at subscription time.

Note - When the interface is implicitly identified, octet 3b is omitted.

<u>#/Map</u> (Octet 4, 5a)

0 : (sub-) channel is indicated by the number (#)
1 : (sub-) channel is indicated by the slot map (Map)

<u>Note</u> - If map element type is 8 kbit/s, then only "1" is allowed.

<u>(Sub-) channel type/Map (sub-) element type</u> (Octet 4, 5a)

0 0 0 1 : 8 kbit/s sub-channel
0 0 1 1 : B-channel
0 1 1 0 : HO-channel
1 0 0 0 : Hl-channel

<u>Note</u> - All other values are reserved for further study.

<u>(Sub-) channel #</u> (Octet 5, 5b)

Binary number assigned to the channel.

<u>Note 1</u> - Bit 8 is reserved for extension.

<u>Note 2</u> - Either "Channel #" or "Slot map" is used exclusively, depending on the "#/Map" information.

<u>(Sub-) Slot map</u> (Octet 5, 5b)

Bit position(s) in slot map corresponding to time slot(s) used by the (sub-) channel is set to 1. Some examples are listed below.

<u>Note</u> - Length of the slot-map is decided by combination of unit on which the slot map is mapped and map element.

Case 1 : Primary rate interface, map element = B-channel

8	7	6	5	4	3	2	1
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

1.5 M

2 M

Case 2 : B-channel, map element = 8 kbit/s sub-channel

8	7	6	5	4	3	2	1
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

Coding standard (Octet 4, 5a)

0 0 : CCITT standard
0 1 : reserved for other international standard
1 0 : national standard
1 1 : standard specific to the network present on the network side of the interface

Examples of channel identification :

8	7	6	5	4	3	2	1
Channel identification information element identifier							
0	0	1	1	1	0	0	0
0	0	0	0	0	0	0	1
Length							
1 Ext	0 Int id	0 Int type	0 Spare	1 Ext	0 D-ch ind	1 Info chan selection	0

- Basic interface
- Implicit Int id
- B2-ch exclusive
- No sub-channel

Channel identification information element identifier							
0	0	1	1	1	0	0	0
0	0	0	0	0	0	0	1
Length							
1 Ext	0 Int id	0 Int type	0 Spare	0 Pref	1 D-ch ind	1 Info chan selection	1

- Basic interface
- Implicit Int id
- D- or any B-channel
- No sub-channel

Channel identification							
0	0	1	1	1	0	0	0
information element identifier							
0	0	0	0	0	1	1	0
Length							
1	1	1	0	0	0	0	1
Ext	Int id	Int type	Spare	Pref	D-ch id	Info chan selection	
1	0	0	0	0	0	1	1
Ext	(Interface # 3)						
1	0	0	0	0	0	1	1
Ext	(CCITT St)		(#)	(B-channel)			
1	0	0	0	1	1	0	0
Ext	(Channel # 12)						
1	0	0	1	0	0	0	1
Ext	(CCITT St)		(Map)	(8 kbit/s slot map element)			
1	1	0	0	0	0	0	0
(16 kbit/s sub-channel)							

- Other interface
- # 3 interface (e.g. Primary rate)
- 16 kbit/s sub-channel in # 12 B-channel preferred

4.5.11 Compatibility

The purpose of the compatibility information element is to provide a means which, in association with the bearer service information element, may be used by the network or the remote user in compatibility checking. The use and the detailed coding of this information element is for further study.

The compatibility information element is coded as shown in Figure 4-16/Q.930. The compatibility information element may be repeated in a message to convey information related to more than one CCITT Recommendation. The network will assume that only a Recommendation I.200 bearer service is to be provided when the compatibility information element is absent.

Note - When an ISDN provides bearer services, this information is not interpreted by the network, but rather is carried transparently and delivered to the remote user(s). If explicitly requested by a user (on a per call basis or at subscription time), a network which provides some capabilities to realize telecommunication services may interpret this information to provide a particular service.

8	7	6	5	4	3	2	1	
0	Compatibility 1	1	1	1	1	0	0 information element identifier	Octet 1
Length of compatibility information								2
0/1 Ext	Coding standard		Profile					3
Optional detailed description, according to the Recommendation specified in the profile (for further study)								4 etc.

Extension bit (Octet 3)

0 : description is extended through the next octet
1 : last octet of the description

Coding standard (Octet 3)

0 0 : CCITT standard
0 1 : reserved for other international standards
1 0 : national standard
1 1 : standard specific to the network present on the network side of the interface.

Profile (Octet 3)

5	4	3	2	1	
0	0	0	0	1	Recommendation X.25

Examples of other candidates which may be coded as CCITT standard are :

- Recommendations S.61, 62 (Teletex)
- Recommendation T.a, b (Facsimile)
- Recommendation S.100 (Videotex).

Note - See bearer-service information element for description of coding laws, e.g. for telephony.

FIGURE 4-16/Q.930

Compatibility information element

4.5.12 Congestion level

The purpose of the congestion level information element is to describe the congestion status of the call. It is a single octet information element coded as shown in Figure 4-17/Q.930.

8	7	6	5	4	3	2	1	
Congestion level 1 0 1 1 information element id.				Congestion level				Octet 1

Congestion level (Octet 1)

4	3	2	1	
0	0	0	0	receiver ready
0	0	0	1	for further study
to				
1	1	1	0	
1	1	1	1	receiver not ready

FIGURE 4-17/Q.930

Congestion level information element

4.5.13 Connected address

The purpose of the connected address information element is to indicate which address is connected to a call. The connected address(es) may be different from the origination or destination address(es) because of changes (e.g. call redirection, transfer) during the lifetime of the call.

The connected address information element is coded as shown in Figure 4-18/Q.930. The connected address may be repeated in a message, e.g. for a multipoint call.

8	7	6	5	4	3	2	1	
0	Connected address 0	0	0	1	1	0	0 information element identifier	Octet 1
Length of connected address information								2
Even/odd	Reserved (See Note 2)			Type of address				3
Address digits				0	0	0	0 (fill)	4 etc.

Note - This figure is drawn assuming an odd number of address digits. Within each octet, the address digit in bits 5-8 are considered to precede the digit in bits 1-4. The address digits in octet 4 precede the digits in octet 5, etc. The address digit to be dialled first is denominated digit 1, etc. In case of an odd number of address digits bits 1 to 4 of the last octet shall be set to zero.

FIGURE 4-18(1/2)/Q.930

Connected address information element

Even-odd (Octet 3 bit 8):
0 = even number of address digits.
1 = odd number of address digits.

Reserved (octet 3):
Note 2: Octet 3 bits 4-7 are reserved for possible use as public/private numbering plan indication if such an indication will not be universally provided, as a CCITT standard, in the address digit sequence in the information element.

Type of address (Octet 3)

3 2 1		
0 0 0	unknown.	
0 0 1	international number.	and possibly the sub-address when provided. (see Note)
0 1 0	national number.	
0 1 1	network-specific number.	
1 0 0	local (directory) number.	
1 0 1	subaddress.	
1 1 0	abbreviated address.	
1 1 1	continuation of address (e.g., overlap sending).	

Note - The need to have the subaddress conveyed together with other address information in a single address information element is for further study. However, if the subaddress is conveyed within a separate specific address element, that element shall immediately follow that address information element conveying the remainder of the address information.

Address digits (octets 4 etc.)

4 3 2 1 or 8 7 6 5	address digit value
0 0 0 0	0
0 0 0 1	1
0 0 1 0	2
0 0 1 1	3
0 1 0 0	4
0 1 0 1	5
0 1 1 0	6
0 1 1 1	7
1 0 0 0	8
1 0 0 1	9
1 0 1 0	A
1 0 1 1	B
1 1 0 0	C
1 1 0 1	D
1 1 1 0	*
1 1 1 1	#

Note - The possible need to allocate one of these codes to also represent end of address is for further study.

FIGURE 4-18(2/2)/Q.930

Connected address information element

4.5.14 Destination address

The purpose of the destination address information element is to identify one destination of a call.

The destination address information element is coded as shown in Figure 4-19/Q.930. The destination address information element may be repeated in a message; e.g. for a multipoint call.

8	7	6	5	4	3	2	1	
	Destination address							
0	1	1	1	0	0	0	0	Octet 1
	information element identifier							
length of destination address information								2
even-odd	Reserved (see Note 2)			Type of address				3
Address digits								4 etc.
				0	0	0	0	
				(fill)				

Note: The contents of this information element are coded as shown in Figure 4-18/Q.930.

FIGURE 4-19/Q.930

Destination address information element

4.5.15 Display

The purpose of the display information element is to supply information. The information contained in this element is coded in IA5 characters.

The display information element is coded as shown in Figure 4-20/Q.930.

8	7	6	5	4	3	2	1	
Display 0	0	1	0	1	0	0	0	Octet 1
information element identifier								
Length of display information								2
Display information								3 etc.

FIGURE 4-20/Q.930

Display information element

4.5.16 Keypad

The purpose of the keypad information element is to convey IA5 characters e.g. entered by means of a terminal keypad.

The keypad information element is coded as shown in Figure 4-21/Q.930.

8	7	6	5	4	3	2	1	
Keypad 0	0	1	0	1	1	0	0	Octet 1
information element identifier								
Length of keypad information								2
IA5 information								3 etc.

FIGURE 4-21/Q.930

Keypad information element

4.5.17 Keypad echo

The purpose of the keypad echo information element is to convey IA5 information echoed to the user by the network.

The keypad-echo information element is coded as shown in Figure 4-22/Q.930.

8	7	6	5	4	3	2	1	
0	0	1	1	0	0	0	0	Octet 1
Keypad echo information element identifier								
Length of keypad echo information								2
IA5 information								3 etc.

FIGURE 4-22/Q.930

Keypad echo information element

4.5.18 More data

The more data information element is sent by the user to the network in a USER INFO message, and delivered by the network to the destination user(s) in the corresponding USER INFO message.

The use of the more data information element is not supervised by the network.

The more data information element is coded as shown in Figure 4-23/Q.930.

8	7	6	5	4	3	2	1	
1	0	1	0	0	0	0	0	Octet 1
	More data information element identifier							

FIGURE 4-23/Q.930

More data information element

4.5.19 Network-specific facilities

The purpose of the network-specific facilities information element is to indicate which network facilities are being invoked at the specified network.

The network-specific facilities information element is coded as shown in Figure 4-24/Q.930.

8	7	6	5	4	3	2	1	
0	Network-specific facilities 0	1	0	0	0	0	0 information element identifier	Octet 1
Length of network-specific facilities information element								2
Length of network identification								3
Even-odd	Nature of network 0	0	0 identification plan	0 Spare	Type of network identification			4*
Network identification digits				0	0	0	0 fill	4a*
Network-specific facility specification								5 etc.

Note - This figure is drawn assuming an odd number of network identification digits. Within each octet, the network identification digit in bits 5-8 are considered to precede the digit in bits 1-4. The network identification digits in octet 4 precede the digits in octet 5, etc. In case of an odd number of digits bits 1 to 4 of the last octet shall be set to zero.

* May be omitted.

FIGURE 4-24/Q.930

Network-specific facilities information element

Length of network identification (Octet 3) :

This field contains the length, in octets, of the network identification found in octets 4, 4a etc. If the value is "0000 0000", then the local serving network is assumed.

Even-odd (Octet 4, bit 8) :

0 = even number of network identification digits.
1 = odd number of network identification digits.

Type of network identification (Octet 4) :

3 2 1	meaning
0 0 0	unknown
0 1 0	national network number.

Reserved (Octet 4) :

Octet 4, bits 5-7 are reserved for possible use as a network numbering plan indication. The value "0000" is reserved to indicate "unknown".

Network identification digits (Octets 4a, etc.) :

These digits are organized and encoded as shown for address digits (Octets 4, etc.) in Figure 4-18/Q.930.

Network-specific facilities (Octet 5, etc.) :

This field is encoded according to the rules specified by the identified network.

4.5.20 Origination address

The purpose of the origination address information element is to identify the origin of a call.

The origination address information element is coded as shown in Figure 4-25/Q.930.

8	7	6	5	4	3	2	1	
0	Origination address 1	1	0	1	1	0	0 information element identifier	Octet 1
Length of origination address information								2
Even-odd	Reserved (see Figure 4-18/Q.930, Note 2)			Type of address				3
Address digits				0	0 (fill)	0	0	4 etc.

Note - The contents of this information element are coded as shown in Figure 4-18/Q.930.

FIGURE 4-25/Q.930

Origination address information element

4.5.21 Redirecting address

The purpose of the redirecting address information element is to identify a point at which call redirection/diversion/transfer was invoked.

The redirecting address information element is coded as shown in Figure 4-26/Q.930. The redirecting address information element may be repeated in a message in case of multiple redirections.

Note - The distinction between call redirection, call diversion and transfer, if any, is for further study.

8	7	6	5	4	3	2	1	
0	1 Redirecting address information element identifier	1	1	0	1	0	0	Octet 1
Length of redirecting address information								2
Even-odd	Reserved (See Figure 4-18/Q.930,Note 2)			Type of address				3
Address digits				0	0 (fill)	0	0	4 etc.

Note - The contents of this information element are coded as shown in Figure 4-18/Q.930.

FIGURE 4-26/Q.930

Redirecting address information element

4.5.22 Signal

The purpose of the signal information element is to convey indications causing a stimulus mode terminal to generate tones and alerting signals.

The signal information element is coded as shown in Figure 4-27/Q.930.

The signal information element may be repeated in a message to convey multiple stimuli.

8	7	6	5	4	3	2	1	
Signal								
0	0	1	1	0	1	0	0	Octet 1
information element identifier								
0	0	0	0	0	0	0	1	2
Length of signal information element								
Signal value								3

Signal value (Octet 3)

0 0 0 0	0 0 0 0	dial tone on
0 0 0 0	0 0 0 1	ring back tone on
0 0 0 0	0 0 1 0	intercept tone on
0 0 0 0	0 0 1 1	network congestion tone on
0 0 0 0	0 1 0 0	busy tone on
0 0 0 0	0 1 0 1	confirm tone on
0 0 0 0	0 1 1 0	answer tone on
0 0 0 0	0 1 1 1	call waiting tone on
0 0 0 0	1 0 0 0	off-hook warning tone on
0 0 1 1	1 1 1 1	tones off
0 1 0 0	0 0 0 0	alerting on - pattern 0
0 1 0 0	0 0 0 1	alerting on - pattern 1
0 1 0 0	0 0 1 0	alerting on - pattern 2
0 1 0 0	0 0 1 1	alerting on - pattern 3
0 1 0 0	0 1 0 0	alerting on - pattern 4
0 1 0 0	0 1 0 1	alerting on - pattern 5
0 1 0 0	0 1 1 0	alerting on - pattern 6
	0 1 1 1	alerting on - pattern 7
0 1 0 0	1 1 1 1	alerting off

FIGURE 4-27/Q.930

Signal information element

4.5.23 Switchhook

The purpose of the switchhook information element is to indicate the state of the stimulus mode terminal switchhook to the network.

The switchhook information element is coded as shown in Figure 4-28/Q.930.

8	7	6	5	4	3	2	1	
0	0	1	1	0	1	1	0	Octet 1
Switchhook information element identifier								
0	0	0	0	0	0	0	1	2
Length of switchhook information element								
0	0	0	0	0	0	0	Switch-hook value	3
Spare								

Switchhook value (Octet 3, bit 1)

0 - on-hook
1 - off-hook.

FIGURE 4-28/Q.930

Switchhook information element

4.5.24 Terminal capabilities

The terminal capabilities information element is used by stimulus mode terminals to indicate their capabilities to the network.

The terminal capabilities information element is coded as shown in Figure 4-29/Q.930.

8	7	6	5	4	3	2	1	
Terminal capabilities								
0	0	1	0	0	1	0	0	Octet 1
information element identifier								
0	0	0	0	0	0	0	1	2
Length of terminal capabilities								
Coding standard		Capability description						3

Coding standard (Octet 3)

8 7	
0 0	CCITT standard
0 1	reserved for other international standards
1 0	national standard
1 1	standard specific to network on network side of the interface.

Capability description (Octet 3)

6 5 4 3 2 1	
0 0 0 0 0 0	stimulus mode terminal

FIGURE 4-29/Q.930

Terminal capabilities information element

4.5.25 Transit network selection

The purpose of the transit network selection information element is to identify one requested transit network. The transit network selection information element may be repeated in a message to select a sequence of transit networks through which a call must pass.

The transit network selection information element is coded as shown in Figure 4-30/Q.930.

<table>
<tr><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td></td></tr>
<tr><td rowspan="2">0</td><td colspan="7">Transit network selection</td><td rowspan="2">Octet 1</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td></td><td colspan="7">information element identifier</td><td></td></tr>
<tr><td colspan="8">Length of transit network identification</td><td>2</td></tr>
<tr><td rowspan="2">Even-odd</td><td colspan="3">Nature of network</td><td rowspan="2">0
Spare</td><td colspan="3">Type of network</td><td rowspan="2">3</td></tr>
<tr><td>0</td><td>0</td><td>0
identification plan</td><td colspan="3">identification</td></tr>
<tr><td colspan="8">Network identification</td><td rowspan="2">4 etc.</td></tr>
<tr><td></td><td></td><td></td><td></td><td>0</td><td>0 fill</td><td>0</td><td>0</td></tr>
</table>

Note - The contents of this information element are coded as shown in Figure 4-24/Q.930, octets 4, 4a, etc.

FIGURE 4-30/Q.930

Transit network selection information element

4.5.26 User-user information

The purpose of the user-user information element is to convey information between ISDN users. This information is not interpreted by the network, but rather is carried transparently and delivered to the remote user(s).

The user-user information element is coded as shown in Figure 4-31/Q.930. There are no restrictions on the content of the user information field.

In SETUP, ALERTing, CONNECT, DISConnect, DETach, and RELease messages, the user information field contained inside this information element has a network-dependent maximum size of 32 or 128 octets. The evolution to a single maximum value is the long-term objective, the exact maximum value is the subject of further study.

In USER INFO messages sent in association with a circuit-mode connection, the user information field contained inside this information element has a maximum size of 32 octets. For USER INFO messages sent in a temporary or permanent user-user signalling connection, the user information field contained inside this information element has a maximum size equal to the maximum size of messages defined in section 4 (excluding USER INFO).

8	7	6	5	4	3	2	1	
0	User-user information 1	1	1	1	1	1	0 information element identifier	Octet 1
Length of user information								2
User information								3 etc.

FIGURE 4-31/Q.930

User-user information element

5. Call control procedures

The call states referred to in this section cover the states perceived by the network, states perceived by the user and states which are common to both user and network. Unless specifically qualified, all states described in the following text should be understood as common (see §§ 2.1.1 and 2.1.2 for user and network call states respectively). An overview diagram of call states is given in §§ 2.1.3 and 2.1.4.

Provisional detailed specification and description language (SDL) diagrams and state transition tables for the procedures specified in this section are contained in Figures 5- /Q.930 through 5- /Q.930. Points requiring further study are indicated in both the text of this section and these SDL diagrams.

5.1 Procedures for circuit-switched calls

Circuit-switched calls are controlled by a sequence of messages flowing across the user-network interface. This section describes the sequence.

All messages in this Recommendation may contain two types of information element, functional and/or stimulus. Functional information elements are characterized as requiring a degree of intelligent processing by the terminal in either their generation or analysis. Stimulus information elements, on the other hand, are either generated as a result of single event at the user/terminal interface (e.g. key depression) or contain a basic instruction from the network (e.g. display) to be executed by the terminal.

Functional information elements will always be used in a standardized way. Stimulus information elements mentioned in § 5 and § 7.1 to § 7.4 of this Recommendation will also be standardized. The precise meaning and application of additional stimulus information elements (see § 7.5) is for further study.

As a general principle, all the messages sent by the network to the terminals may contain a "Display" information element whose contents may be displayed by the terminal; the content of this information element shall be network dependent.

In addition to the messages exchanged as described in the following sections, INFORMATION messages for call control may be sent by a terminal or by the network at any time of the call (i.e. after the terminal has issued or received a set-up message and before it has sent or received a disconnect message). Unless specified in the following text, the INFORMATION message may contain both stimulus and functional information elements. The stimulus type information elements "Keypad" and "Display" shall contain strings of IA5 characters arranged according to network dependent rules. Other stimulus information elements shall not be subject to the same coding restrictions.

Note - "Keypad" information elements shall only be conveyed in the direction user to network since their contents represent the depression of keypad buttons or an equivalent pre-programmed key at the user interface. "Display" information elements shall generally be conveyed in the direction network to user but may be generated by the user in some circumstances (see § 5.2).

5.1.1 Call establishment at the originating exchange

Before these procedures are invoked, a reliable data link connection must be established between the user (TE/NT2) and the network. The data link services described in Q.920 (I.441) are assumed.

5.1.1.1 Call request

a) General

A user initiates call establishment by transferring a SETUP message across the user network interface. Following the transmission of the SETUP message, the call shall be considered by the user to be in the CALL INITIATED state. The message shall always contain a call reference, selected according to the procedures given in § 4.3; where the terminal has a single B-channel connection per layer 2 end point capability with one call at a time, a dummy call reference value (i.e. all zero) shall be used. At least, the bearer service information element is contained in the message even in the case of overlap sending. This information element is assumed to be an exclusively functional information element.

Furthermore the SETUP message may also contain all or part of the call information (i.e. address and facility requests) necessary for call establishment depending on whether or not en-bloc or overlap procedures are being used respectively (see § 5.1.1 b)). This call information may be included within "keypad" information elements or in other functional information elements (e.g. called address, CUG identity .....). A mixture of keypad information and functional information for conveying call information is not precluded. However, a given element of the call information (e.g. addressing) must be sent in a unique way (i.e. keypad or functional).

b) Call information sending

If en-bloc sending is used, the SETUP message should contain all the information required from the user by the network to process the call. The network sends a CALL SENT message to the user to acknowledge the SETUP message and to indicate that the call is being processed. The CALL SENT message contains the B-channel allocated to the call and to which the user must be attached. At this point, the call enters the CALL SENT state.

If overlap sending is used, the SETUP message will contain only part of the information required by the network to process the call. On receipt of such a SETUP message, the network initializes timer T302 and sends a SETUP ACKNOWLEDGE message to the user. If the SETUP did not contain any element of call information, the network will also return dial tone, if appropriate, based on an analysis of the bearer service information element.

The SETUP ACKNOWLEDGE message contains the information element "signal - dial on"; when received by a user this information element may initiate a local indication that dialling can start (e.g. by an audible or visual indication). The SETUP ACKNOWLEDGE message also contains the B-channel to be used.

If following the receipt of an en-bloc SETUP message or during overlap sending, the network determines that the call information received from the user is invalid (i.e. invalid facility request or address), then the network shall initiate clearing by sending a DISCONNECT message to the user (see § 5.1.3.2).

After receiving the SETUP ACKNOWLEDGE message, the user sends the remainder of the call information in one or more information messages. If dial tone has been returned, it will be terminated by the network on receipt of the first INFORMATION message. The call information in the message which completes the information sending may contain a "sending complete" indication i.e. as part of the called address. The network shall re-initialize timer T302 on the receipt of every INFORMATION message not containing a sending complete indication and optionally generates an INFORMATION message containing a keypad information element (for echo).

Following the occurrence of one of the conditions described below, the network shall send a CALL SENT message to the user and cancel timer T302 where appropriate :

i) the expiration of timer T302 (the value of T302 requires further study);

ii) the receipt by the network of a sending complete indication;

iii) analysis by the network that all call information necessary to effect call establishment has been received.

Note - With regard to case i), an alerting or connect indication can be received from the called party before timer T302 expires and in such cases an ALERTING or CONNECT message shall be sent to the calling user. No CALL SENT message shall be sent and T302 shall be cancelled.

c) B-channel selection - originating

In the SETUP message, the user will indicate one of the following :

i) a preferred channel with no acceptable alternative;

ii) a preferred channel, any alternative is acceptable;

iii) any channel is acceptable.

If no indication is included alternative iii) is assumed.

In cases i) and ii), if the preferred channel is available, the network reserves it for the call.

In case ii), if the network cannot grant the specified channel, it reserves any other available B-channel associated with the D-channel.

In case iii), the network reserves any available B-channel associated with the D-channel.

The reserved B-channel is indicated in the first message returned by the network in response to SETUP (i.e. SETUP ACKNOWLEDGE or CALL SENT). This message may also be used to activate the B-channel connection in the user's equipment.

In case i), if the specified channel is not available, and in cases ii) and iii), if no channel is available, a DISCONNECT message, indicating this condition, is sent by the network. However, if the network provides facilities in the "no channel available" condition (e.g. delayed call establishment), it may instead return a SETUP ACKNOWLEDGE or CALL SENT message as appropriate.

When the "no channel available" condition is indicated in the SETUP ACKNOWLEDGE or CALL SENT message, the user may clear the call or initiate alternative procedures instead of clearing. Alternate procedures, for example, to request delayed call establishment by the exchange when a channel becomes available, are for further study.

A network timer T301 is initialized when the SETUP ACKNOWLEDGE message is sent indicating that no channel is available, and the timer T301 is reset when the user initiates either clearing or some other procedure permitted to the user. If the timer expires, the network initiates clearing by sending a DISCONNECT message to the user (see § 5.1.3.2). The value of T301 is for further study.

5.1.1.2 Call sent

After completion of channel selection, and when the network has received sufficient call information, it determines whether the call can be established as requested. If access to any services and facilities requested is not authorized for the user, the network initiates clearing of the call with a cause indicated in the DISCONNECT message sent to the user. Alternative procedures, for example, indicating call failure without initiating clearing, are for further study.

If access to requested services and facilities is authorized but not presently available, the network shall initiate clearing of the call (see § 5.1.3.2). However, if the network provides call queueing facilities, it may place the call on a queue for the requested service or facility. The D-channel messages and in-band tones/ announcement to be returned by the network in such circumstances and the network's subsequent treatment of the call require further study.

If access to the requested service and facilities is authorized and available, the network proceeds with call establishment.

If the user corresponding to the called address and the calling user are served by the same exchange, procedures given in 5.1.2 are initiated.

If the user corresponding to the called address is served by another exchange, appropriate inter-exchange signalling and switching procedures are initiated.

5.1.1.3 Call confirmation indication

Upon receiving an indication that user alerting has been initiated at the called address, the network transfers an ALERTING message across the user-network interface of the calling address. This message may cause initiation of a user equipment generated alerting indication. At this time, the call enters the CALL-DELIVERED state.

5.1.1.4 Call connected

Upon receiving an indication that the call has been accepted, a CONNECT message is sent across the user-network interface to the calling user.

This message indicates to the calling user that a connection has been established through the network and stops a possible local indication of alerting. At this time, the call enters the ACTIVE state.

On receipt of the CONNECT message, the calling user may optionally generate a CONNECT ACKNOWLEDGE message. The network shall not take any action on receipt of this message when it perceives the call to be in the ACTIVE state.

5.1.1.5 Call rejection

Upon receiving an indication that the remote user (or network) is unable to accept the call, the network will initiate clearing.

5.1.2 Call establishment at the destination exchange

This procedure assumes that a reliable data link connection providing services described in Q.920 (I.441) may not exist before the first layer 3 message (SETUP) is transferred across the interface. However, reliable data link connections must be established by each of the users (terminals and/or NT2s) at the interface before they respond to the SETUP message. Permanent data link connections are not precluded, and may be recommended as a national option. The call reference contained in all messages exchanged across the user-network interface shall have the value specified in the SETUP message delivered by the network. However, when a user has only a single B-channel connection per layer 2 endpoint capability, it shall use a dummy value (all zero) for the call reference in all messages except the first response to the SETUP message. This response, being an ALERTING, CONNECT or RELEASE message must contain the terminal capabilities information element, indicating the terminal can only support a single B-channel connection per layer 2 endpoint capability.

5.1.2.1 Incoming call

The network will indicate the arrival of a call at the user-network interface by transferring a SETUP message across the interface. This message is sent if the network can select an idle B-channel. If the network provides facilities in "no B-channel condition" (e.g. call waiting), the message may also be sent when no B-channel is idle. The possible use of other messages for this purpose (e.g. information) is for further study.

The SETUP message always includes the following information elements :

a) Call reference

b) Bearer service identification

c) Channel identification

In addition, the SETUP message may include, as required, the information elements described in § 3.2.24 (e.g. display, compatibility, signal (alerting-on)).

Since a multipoint terminal configuration may exist at the user-network interface, this message must be sent using a broadcast capability at the data link layer. In this case, the SETUP message should contain the DDI address where appropriate and sub-address if provided. However if the network has knowledge that a single-point configuration exists at the interface, a point-to-point link may be used to carry the SETUP message. After sending the SETUP message, the call is in the CALL-PRESENT state. The network initializes timer T303.

Note - In the case of overlap sending within the network, the DDI or sub-address may also be conveyed by means of INFORMATION messages to the called user in the point-to-point configuration.

5.1.2.2 B-channel negotiation

i) Basic interface structure

When the network selects an idle B-channel for a call, terminals on a basic access can only accept the call on the channel indicated in the SETUP message. Further study is required on the need for channel negotiation when a single point configuration exists on a basic access.

ii) Primary rate interface structure

In point-to-point primary rate interface structures (e.g. PABX), negotiation between the network and user will be permitted on the selection of the B channel(s) for the call. Only B-channels which are controlled by the same D-channel will be used in the negotiation procedure. The negotiation procedure is as follows :

1) if the call can be accepted using the B-channel(s) indicated in the SETUP message, an ALERTING or CONNECT message is sent to the network indicating those B-channel(s);

2) if the call cannot be accepted using the B-channel(s) indicated in the SETUP message, a SETUP ACKNOWLEDGE message is sent to the network indicating alternative B-channel(s);

3) when the network receives a SETUP ACKNOWLEDGE message, it responds with an INFORMATION message indicating either :

   a) the B-channel indicated in the SETUP ACKNOWLEDGE message (negotiation successfully terminated);

   b) a second alternative B-channel;

   c) the same B-channel indicated in the SETUP message. After sending this message, the network re-initializes timer T303;

4) the user response in case 3 a) above is an ALERTING or CONNECT message;

5) in cases 3 b) and 3 c) above, if the call can be accepted on the B-channel selected by the network, an ALERTING or CONNECT message indicating that B-channel is sent;

6) in cases 3 b) and 3 c) above, if the call cannot be accepted on the B-channel selected by the network, a RELEASE message is sent to the network and the procedure of § 5.1.3.1 is followed;

7) if the timer T303 expires after re-initializing and the network has not received either an ALERTING, CONNECT or RELEASE message, then the network initiates clearing using the procedure in § 5.1.3.2.

5.1.2.3 Call confirmation

a) Basic interface structure

Idle user's equipment which satisfies the compatibility requirements indicated in the SETUP message responds with either an ALERTING, CONNECT, FACILITY (e.g. for call forwarding, hold....), or information message.

The INFORMATION message contains the same request as the FACILITY message in specifically defined information elements, or KEYPAD information elements.

Busy user's equipment which satisfies the compatibility requirements indicated in the SETUP message responds with a RELEASE, ALERTING, (e.g. for call waiting) and/or FACILITY/INFORMATION message.

If the compatibility requirements indicated in the SETUP message are not satisfied or the user wishes to refuse the call, a RELEASE message may be sent with the cause "call rejected" and the user should then assume the call to be in a NULL state.

In both the above cases, receipt of an ALERTING or CONNECT message causes a corresponding ALERTING or CONNECT message to be sent to the calling user and timer T303 is cancelled. The effect of the FACILITY message on timer T303 is for further study. Where multiple ALERTING messages are received in a multipoint access line, only the first is treated in this way. When the first CONNECT message is received, the network sends a RELEASE message to the remaining responding terminals. In all the above cases, receipt of a valid FACILITY or INFORMATION message causes calling user treatment appropriate to the facility requested. Such treatment is for further study.

The use of a SETUP message when no B-channel is available is for further study.

b) Primary rate interface structure

User equipment (intelligent NT2 type) can respond to the SETUP message with a SETUP ACKNOWLEDGE, ALERTING, CONNECT, FACILITY/INFORMATION or RELEASE message. Receipt by the network of an ALERTING or CONNECT message causes a corresponding ALERTING or CONNECT message to be sent to the calling user, and timer T303 is cancelled. Some types of user equipment may respond as described for the basic access interface.

The use of a SETUP message when no B-channel is available is for further study.

c) Failure procedures

If the network does not receive any response to the SETUP message within a time interval T303, the SETUP message is retransmitted. If no response is received during a further period T303, from the message retransmission, the network initiates clearing procedures. The value of T303 is for further study. The clearing cause sent to the calling user is "no user responding".

If a RELEASE message is received whilst T303 is running, the message cause shall be retained by the network and returned in a DISCONNECT message to the calling user if T303 expires (i.e. if no valid ALERTING/CONNECT message has been received from the user).

Further study is required regarding the action to be taken by the network when multiple REL messages are received with different causes.

5.1.2.4 Call accept

A user indicates acceptance of an incoming call by transferring a CONNECT message across the user-network interface towards the network. If an ALERTING message had previously been sent to the network, the CONNECT message may contain only the call reference. The CONNECT message may also contain the switchhook information element (Off-hook).

If a call can be accepted using the B-channel indicated in the SETUP message, and no user alerting is required, a CONNECT message may be sent without a previous ALERTING message. In this instance, the CONNECT message contains the call reference and B-channel specified in the SETUP message.

Note - Further study is required on the need for means to avoid service degradation or speech clipping on connections involving an NT2.

5.1.2.5 Active indication

On receipt of a CONNECT message, the network completes the circuit switched path to the selected B-channel and sends a CONNECT ACKNOWLEDGE message to the user which accepted the call. The CONNECT ACKNOWLEDGE message includes the call reference and B-channel specification. It may contain the signal information element (alerting-off). The network also initiates procedures to send a CONNECT message towards the calling user.

The CONNECT ACKNOWLEDGE message indicates completion of the circuit switched connection. There may not be end-to-end communications until the CONNECT indication is received at the calling user. At this point, the call enters the ACTIVE state where it remains until clearing is initiated or until the call is suspended.

5.1.2.6 Non selected user clearing

In addition to sending the CONNECT ACKNOWLEDGE message to the terminal selected for the call, the network sends a RELEASE message to all other terminals at the interface which had sent an ALERTING or CONNECT message in response to a SETUP message. This message is used to notify these terminals that the call is no longer offered to them. Each user receiving the message will return a RELEASE ACKNOWLEDGE message and then consider the call to have returned to a NULL state. The network shall maintain a timer T308 in accordance with § 5.1.3, and shall retransmit, the RELEASE message if necessary.

5.1.3 Call clearing

5.1.3.1 Clearing by the user

a) At any time the user may initiate clearing by transferring across the user-network interface a DISCONNECT message. Following the receipt of a DISCONNECT message, the network shall consider the call to be in the DISCONNECT REQUEST state.

If the network immediately clears the call, the B-channel used in the call is disconnected and a RELEASE message shall be sent to the user. On receipt of the RELEASE message the user shall release the B-channel and the call reference and send in response a RELEASE ACKNOWLEDGE message.

Following the transmission of the RELEASE message, the network shall start timer T308. Following the receipt of a RELEASE ACKNOWLEDGE message from the user, the network shall cancel timers T308 and both the B-channel and the call reference shall be released for future use. If a RELEASE ACKNOWLEDGE message is not received before timer T308 expires, the RELEASE message shall be retransmitted and timer T308 shall be reinitialized. If no RELEASE ACKNOWLEDGEMENT is received from the user before timer T308 expires a second time, the network shall release both the B-channel and the call reference for future use.

The RELEASE message has only local significance and does not imply an acknowledgement of clearing from the remote user.

b) In some cases, network facilities may require the network to retain the call reference for subsequent use after disconnecting the B-channel used for a call. The network shall inform the user of this condition by sending a DETACH message in response to the DISCONNECT message received from the user. The call shall then be considered by the network to be in a DETACHED state.

After the network has completed processing associated with the call, it shall send a RELEASE message with appropriate information to the user, and the procedures in a) above are followed.

The network shall respond to all messages received from the user whilst the call is in the DETACHED state by sending a DETACH message.

c) In other cases, the B-channel connection may be retained by the network after if receives a DISCONNECT message (e.g. for emergency services). The network shall inform the user of this condition by sending a DELAYED DISCONNECT message in response to the DISCONNECT message received from the user. The network shall respond to all messages subsequently received from the user by sending a DELAYED DISCONNECT message. Sending of DELAYED DISCONNECT messages will not change the state of the call, which will remain in the DISCONNECT REQUEST state.

When the network is willing to complete clearing, it shall send a RELEASE message to the user.

If, after having sent a DELAYED DISCONNECT message, the network wishes to disconnect the B-channel whilst retaining the call reference, it shall send a DETACH message and the procedures in b) above will apply.

Possible procedures to return to the ACTIVE state from the DISCONNECT REQUEST state, such as the reconnection of a call which was held (e.g. for emergency services) in the DISCONNECT REQUEST state by a DELAYED DISCONNECT message, are for further study.

5.1.3.2 Clearing by the network

a) The network initiates clearing by transferring a DISCONNECT message across the user-network interface. At the instant, when the DISCONNECT message is sent by the network, the B-channel used in the call is disconnected but not yet available for further calls.

The user will respond by sending a RELEASE message (except in case b) below). This message indicates the deactivation of this particular transaction (by user) to the network. Receiving this message, the network releases the B-channel and the call reference for future use and returns a RELEASE ACKNOWLEDGE message to the user. If no RELEASE message is received from the user in a time interval T305 from the transmission of the DISCONNECT message, the network shall send a RELEASE message to the user. The network shall start timer T308 and continue as described in § 5.1.3.1 a).

In some networks, in band tones and announcements will be provided as call progress information for calls in which the bearer service identification supplied, as part of the call information by the calling user, has indicated that this would be appropriate. When the network decides to initiate clearing for such calls, the appropriate in band tone shall be sent for a period T306 prior to the transmission by the network of a DISCONNECT message. If a DISCONNECT message is received from the user during a period covered by T306, the network shall remove the tone or announcement from the B-channel and shall send RELEASE message to the user.

b) In some cases, the user may wish to invoke facilities which may delay the release of the call reference whilst allowing the release of the B-channel. In these conditions the user will respond to the DISCONNECT message by sending a DETACH message. On the receipt of the DETACH message, the network shall consider the call to be in a DETACHED state and cancel timer T305.

The network responds to the DETACH message by either :

i) actioning the requested facilities and then sending a RELEASE message to the user;

ii) sending a RELEASE message if the requested facilities are not provided or access to the requested facilities is not permitted to the user.

c) In some cases the user may receive from the network a RELEASE message without having received a previous DISCONNECT message (e.g. if the DISCONNECT message was corrupted by undetected transmission errors). In these cases the user shall return a RELEASE ACKNOWLEDGE message to the network and consider the call to be in the NULL state.

5.1.3.3 Clear collision

Clear collision occurs when the user and the network simultaneously transfer a DISCONNECT message specifying the same call. Both the terminal and the exchange will regard the call as having entered the DISCONNECT REQUEST state. The procedures in § 5.1.3.1 will then apply.

5.1.3.4 Handling of error conditions

a) Whenever a message is received, at either side of the interface, specifying a call which is considered to be in either the ACTIVE state or any of the states of call establishment, suspension or clearing, but for which a response is not prescribed by the procedures in § 5.1 or § 5.2, a STATUS message is returned indicating the call state of the receiver. Subsequent actions taken upon receipt of a STATUS message are for further study (see Table....). The STATUS message and its contents are defined in § 3.2.26.

b) Whenever the network receives any message except SETUP, RELEASE, RELEASE ACKNOWLEDGE or DISCONNECT specifying a call reference which it does not recognize as relating to an active call or a call in progress, it initiates clearing according to the procedure in § 5.1.3.2, specifying the call reference in the received message.

c) Whenever the user receives any message except SETUP, RELEASE, RELEASE ACKNOWLEDGE or DISCONNECT specifying a call reference which it does not recognize as relating to an active call or a call in progress, it initiates clearing according to the procedure in § 5.1.3.1, specifying the call reference in the received message.

d) If the network or user receives a DISCONNECT message specifying a call reference which it does not recognize as relating to an active call or a call in progress it sends a RELEASE message, specifying the call reference in the received message.

e) If the network or user receives a RELEASE message specifying a call reference which it does not recognize as relating to an active call or a call in progress, a RELEASE ACKNOWLEDGE is returned, specifying the call reference in the received message.

f) If the network or user receives a RELEASE ACKNOWLEDGE message specifying a call reference which it does not recognize as relating to an active call or a call in progress, no action should be taken.

g) If layer 3 is notified by the data link layer entity that the underlying data link is disconnected, it should not immediately clear the calls supported by that data link but should attempt to re-establish a data link connection. Although messages in transit during the layer 2 failure may be lost or duplicated during recovery, as an objective, calls which were stable should not be lost if layer 2 can be reconnected within some brief interval (determined by timer T309, to be defined). Also as an objective the layer 3 procedures should provide as robust recovery procedures as possible even for those calls with lost or duplicated messages. The specific procedures to be invoked when there is a layer 2 disconnection are for further study.

5.1.3.5 General rules for message processing

The following rules are listed in order of precedence :

a) when a message is received that is less than three octets long, that message shall be ignored;

b) when a message is received with an OSI network layer protocol discriminator not in accordance with § 4.2, that message shall be ignored.

5.1.4 Call rearrangements

The elements of procedure in this section provide for physical layer and/or data link layer rearrangements after a call has entered the ACTIVE state as defined in § 2.2.1.5. They are intended for application to the basic interface structure; their possible use for primary rate interface structures is for further study.

The activation of this procedure at a user-network interface may correspond to a number of possible events such as the following :

- physical disconnection of user equipment and reconnection at a different connection point in the same user-installation (e.g. comprising a number of logically associated basic interface structures);
- physical replacement of one user equipment by another at the same connection point;
- the human user moves from one equipment to another;
- suspension of call and its subsequent reactivation at the same user equipment and connection point.

The procedures in this section are described in terms of functional messages and information elements. These procedures may also be realized by stimulus information elements within INFORMATION messages, see § 7.

If the procedures for call suspension in this section are not followed prior to the physical disconnection of the terminal from the interface, then the integrity of the call cannot be guaranteed by the network.

The present text may not completely describe the procedures applicable to calls other than a point-to-point call between two users (e.g. a conference call).

5.1.4.1 Call suspension

The procedure is initiated by the user by sending a SUSPEND message, containing the current call reference, to the network. The user may optionally include in this message a bit sequence (e.g. IA5 characters) to be known as the call identity for subsequent reconnection. Where no call identity is included by the user, the network allocates a null-value.

5.1.4.2 Call suspended state

Following the receipt of a SUSPEND message a SUSPEND ACKNOWLEDGE message shall be sent from the network to the user initiating the action, and a network timer T307 shall be initiated. (The value of T307 is for further study.)

At this time, the network will consider the call reference to be released. The B-channel involved in the connection will be reserved until reconnection of the call (or until a clearing cause occurs, e.g. expiry of timer T307). A STATUS message with cause "remote user suspended" to the other address(es) involved in the call with the address of the user which initiated the action.

When the user receives the SUSPEND ACKNOWLEDGE message, it may disconnect the underlying data link connection, if the terminal has to be physically disconnected from the interface.

5.1.4.3 Call suspend error

On receipt of a SUSPEND message, the network will respond by sending a SUSPEND REJECT message if the information contained in the SUSPEND message is not sufficient to avoid ambiguities on subsequent call re-establishment. This will apply, in particular, when at a given user-network interface, a SUSPEND message is received with a call identity sequence already in use, or when the SUSPEND message does not contain any call identity sequence and another call with a null-value is in the SUSPENDED state at that interface.

In this case the state of the call is not altered within the network (i.e. it remains in the ACTIVE state).

5.1.4.4 Call re-establishment

At the connection end where suspension was initiated, the user may request re-establishment of a call after physical reconnection of a terminal by sending a RESUME message containing the call identity used at the time of call suspension. The call reference included in the RESUME message may be the one relating to the suspended call or a new one chosen by the user. B-channel information may be included in the RESUME message, but the "any B-channel available" option specified in § 5.1.1.1 c) shall be used.

If the terminal was physically disconnected from the interface, a data link connection must be re-established by the user before sending the RESUME message.

On receipt of the RESUME message, the network shall re-establish the call in the ACTIVE state, provided that the call was not cleared due to other reasons. The network shall then send a RESUME ACKNOWLEDGE message to the user and it shall cancel timer T307. The RESUME ACKNOWLEDGE will specify the B-channel allocated to the call by the network according to the procedures specified in § 5.1.1.1 c).

If the call is reconnected at the same interface point where it was suspended, then the previously reserved B-channel will be used. Otherwise, any channel may be selected by the network. If the call is reconnected at a different interface point, then the reserved B-channel will be released by the network at the time of reconnection.

The network will also send a STATUS message with cause "remote user resumed" to the other address(es) involved in the call.

No memory of a previously received call identity sequence is kept by the network after sending the RESUME ACKNOWLEDGE message.

If the call had been cleared by the network, the network shall respond to the RESUME message by initiating call clearing in accordance with § 5.1.3.2.

5.1.4.5 Call resume error

If a received RESUME message cannot be actioned by the network (e.g. as a result of the B-channel selection procedure), a RESUME REJECT message should be returned to the requesting user. The state of the call is not altered within the network.

If timer T307 expires before a valid RESUME message is received from the user, the network shall initiate clearing of the call. Moreover, if the associated data link connection was not disconnected, the network shall initiate clearing procedures towards the concerned user as described in § 5.1.3.2.

5.1.5 Call collisions

Call collision occurs when a user's request to establish a call encounters an attempt by the network to establish a call at the same interface. Such a situation could occur if both the network and the user will send a SETUP message at approximately the same time. If the user can support simultaneous calls and sufficient B-channels are available, the collision is resolved by the channel selection procedures in §§ 5.1.1.2 and 5.1.2.2.

If only B-channel is available, the network shall give an incoming call preference over a call request received from the user.

If only one B-channel is available, the user shall generally give preference to the network for call establishment. However, some terminal adaptors supporting existing non-voice terminals (e.g. X.21) may need to resolve call collision by clearing the incoming call and reattempting the outgoing call set-up in order to satisfy the requirements of the "R" interface.

5.1.6 Control of user facilities

5.1.6.1 General

Two procedures for the control of user facilities are defined as follows :

i) control of call related facilities, in connection with a call control procedure, and;

ii) registration/cancellation of facilities, independently from call control procedures and from any particular call.

The application of such procedures to the various user facilities is described in the specification of the procedure relating to the user facilities themselves. Detailed application of these procedures to specific user facilities is for further study.

User facilities may be controlled using either functional information elements carried by FACILITY messages in accordance with internationally standardized procedures or by stimulus information elements conveyed in INFORMATION messages in accordance with network dependent procedures.

5.1.6.2 Control of call related facilities

Requests for call related facilities may be included in call control messages. Additionally the following messages may be used to control call related facilities : FACILITY, FACILITY ACKNOWLEDGE and FACILITY REJECT. Facility control may also be performed by using INFORMATION messages containing KEYPAD, DISPLAY and other stimulus information elements.

The FACILITY message or the INFORMATION message is sent by a user (calling or called) to initiate the procedure to request the concerned facility. It may also be sent by the network to the remote user if the control procedure of the facility requires this user to be involved.

If the control procedure only involves the initiating user, the network responds to the FACILITY message with either a FACILITY ACKNOWLEDGE or FACILITY REJECT message, to respectively indicate completion or rejection of the procedure.

If the facility is activated by using an INFORMATION message, the network responds with an INFORMATION message containing DISPLAY information.

If the control procedure involves the remote user, this user responds to the FACILITY message with either a FACILITY ACKNOWLEDGE or FACILITY REJECT message.

Alternatively where the network informs the remote user of the facility via an INFORMATION message that user shall respond with an INFORMATION message containing Keypad information elements.

The decision to use functional or stimulus signalling shall be taken locally by the network on the basis of user characteristics determined by the network at call establishment or when the user resumes after call suspension.

Following the receipt of such message from the remote user, the network will send the appropriate message to the initiating user.

The above indicating messages may be sent in the active state of the call. Sending of a message does not in itself change the state of the call; however this state may be changed as a result of the facility invoked.

All the above indicated messages contain the call reference appropriate to the call.

5.1.6.3 Registration and cancellation of facilities

The following messages are used to control registration and cancellation of user facilities : FACILITY REGISER, REGISTER ACKNOWLEDGE, REGISTER REJECT, FACILITY CANCEL, CANCEL ACKNOWLEDGE, CANCEL REJECT.

Facility registration and cancellation may also be controlled by using stimulus information elements (e.g. Keypad) within INFORMATION messages. In this case, the network may respond using DISPLAY and/or other stimulus information elements conveyed in INFORMATION messages.

A FACILITY REGISTER or CANCEL message is sent by a user to initiate a registration or cancellation procedure of a user facility. It may also be sent by the network to a remote user is the control procedure of the facility requires this user to be involved.

If the control procedure only involves the initiating user, the network responds to such a message with the appropriate ACKNOWLEDGE or REJECT message to indicate completion or rejection of the procedure.

If the facility requested involves the agreement of a remote user, this user responds to the message with the appropriate ACKNOWLEDGE or REJECT message. The network transfers the message to the initiating user.

The above indicated messages do not relate to a call, however they contain a call reference, which is the same in the REGISTER or CANCEL and ACKNOWLEDGE or REJECT messages of the same procedure. The REGISTER and CANCEL messages may contain the address of the user to which they are destined.

5.1.7 Charging indication

5.1.7.1 General

Charging indication is a feature allowing a user to be informed about the charging of a call. It is for further study if it is to be provided as a standard service feature or as a user facility assigned to the user for an agreed contractual period.

5.1.7.2 Procedures

Charging indication information may be sent by the network to the appropriate user (calling or called) on the following occasions :

i) at the beginning of the call, to indicate the charging rate plus, when applicable, charging units on answer;

ii) during the call, to indicate a change in the charging rate;

iii) during the call, to indicate that N (value for further study) charging units have been charged;

iv) at the end of the call, to indicate the overall charge.

Note - It is for further study how items i)-iv) apply, e.g. if they have to be considered as separate features or if they have to be combined as part of the same feature.

Charging indication information may be sent to the calling user in any of the following messages : SETUP ACKNOWLEDGE, ALERTING, CONNECT, DISCONNECT, RELEASE and INFORMATION. To the called user, it may be sent in the following messages : SETUP, CONNECT ACKNOWLEDGE and INDICATION, DISCONNECT and RELEASE. The INFORMATION message shall be used during the ACTIVE state of the call and no charging indication information shall be sent when the call is in the SUSPENDED state.

5.1.8 Closed user group (CUG)

The closed user group (CUG) facility is assigned to a user for an agreed contractual period. Principles and procedures to be used are in accordance with Recommendations I.320, Q.764 and X.87.

The SETUP message format allows the inclusion of a CUG facility request by a calling user.

Incoming calls associated with a closed user group shall include a CUG facility request in the SETUP message delivered to the called user.

In both cases the facility request may contain an index referring to the particular CUG to which the call is associated. The CUG index shall only have local significance at each user-network interface. If no CUG facility request is included by the calling user in a SET UP message, then the preferential CUG for that customer will be assumed by the network (see Recommendation X.87).

An ISDN user may be registered as a member of several closed user groups, as specified in relevant CCITT Recommendations.

5.1.9 Calling line identification

Calling line identification is a user facility assigned to a user for an agreed contractual period. It applies to all incoming calls to that user. Principles and procedures to be used are in accordance with Recommendations I.320, Q.764 and X.87.

In this case, the SETUP message sent to the called user includes the calling line identity provided by the network, encoded as the origination address information element; the calling line identity may additionally be provided in the "Display" information element, If an ALERTING or CONNECT message is received containing an indication that the called terminal cannot handle such a specific information element (stimulus mode terminal, see section 7), then the network will send a second time the calling line identity by "Display" information in an INFORMATION message.

Some networks may provide calling line identity within the CONNECT ACKNOWLEDGE message.

Note - Delivery of calling line identity to the called user may be subject to agreement by the calling user. The definition of a possible new user facility to allow a calling user to prevent such a delivery is for further study.

5.1.10 Called line identification

Called line identification is a user facility assigned to a user for an agreed contractual period. It applies to all outgoing calls from that user. Principles and procedures to be used are in accordance with Recommendations I.320, Q.764 and X.87.

In this case, the CONNECT message sent to the calling user includes the called line identity. Depending on the capabilities of the calling terminal (i.e. if it is a stimulus mode terminal or not), this identity will be sent as "Display" information or as a specific information element.

Note - Delivery of called line identity to the calling user may be subject to agreement by the called user. The definition of a possible new user facility to allow a called user to prevent such a delivery is for further study.

5.1.11 Charging method selection

The charging method selection facility is assigned to a user for an agreed contractual period.

The SETUP message format allows the inclusion of a charging method selection/indication at the calling user interface and called user interface respectively.

This facility shall allow the following charging methods to be selected/ indicated :

a) normal charging (in this case normal charging shall be assumed in the absence of a facility request);

b) reverse charging (further study is required regarding the exact method of negotiating this facility with the called user);

c) other charging methods (e.g. credit card) require further study.

5.1.12 Call redirection

The call redirection facility is assigned to a user for an agreed contractual period and causes incoming calls to be redirected to an address previously specified by the called user at the time of facility registration.

The user may register a request for call redirection by using the procedures described in section 5.1.3, i.e. either with a FACILITY REGISTER message or with stimulus information in an INFORMATION message.

The principles and procedures by which the network implments this facility shall be in accordance with Recommendations I.320, Q.764 and X.87.

Additional procedures to allow e.g. selective redirection of calls are for further study.

5.2 Procedures for user-to-user signalling

5.2.1 General

User-to-user signalling provides a means of communication between two customers by using as a basis the layer 3 protocol defined in section 5.1.

User-to-user signalling is used to exchange information between two users to provide, for example, additional facilities that are not described in CCITT Recommendation Q.930.

The exchange of user-to-user signalling is limited by flow control procedures provided by the network.

Three possibilities of user-to-user signalling are provided by the network to the users, as follows :

a) user-to-user signalling in association with a circuit-switched connection on the B-channel(s);

b) user-to-user signalling (not associated with a circuit-switched connection) via an end-to-end signalling connection which is dynamically established;

c) user-to-user signalling (not associated with a circuit-switched connection) via an end-to-end signalling connection which is permanently established.

It is for further study how these facilities are provided; for example, as a standard service feature to all users, as a user facility assigned for an agreed contractual period or on a per call basis. Service characteristics including tariff arrangements are for further study by the relevant Study Groups.

Note - Both functional and stimulus modes of conveying user-to-user information may be employed. The use of a combination of modes is not precluded.

5.2.2 User-to-user signalling in association with a B-channel connection

a) Call establishment

A "User-to-user information" information element of variable length as specified in section 4.5.2.6 may be included in the SETUP message transferred across the user-network interface at the calling side as described in section 5.1.1.1. The content of this information element is transferred in the network and delivered in the same information element included in the SETUP message transferred across the user-network interface at the called side as described in section 5.1.2.1.

"Keypad" information element(s) may also be used to convey user-to-user information in the SETUP message provided that the remaining elements of call information are also conveyed in this manner. User-to-user information received by the network within "Keypad" information elements shall be delivered to the called user via a "Display" information element within the SETUP message.

The character sequences used to delimit the user-to-user information with "Keypad/Display" information elements in a SETUP message whilst maintaining code transparency shall be a network dependent matter.

The maximum amount of user-to-user information which may be conveyed in the SETUP message via "Keypad/Display" information elements is as specified in § 4.5.12.

A "User-user information" information element with the same characteristics may be included in the ALERTING and/or CONNECT messages transferred across the user-network interface at the called side as described in sections 5.1.2.2, 5.1.2.3 and 5.1.2.4. The content of this information element is transferred in the network and delivered in the corresponding message(s) transferred across the user-network interface at the calling side as described in sections 5.1.1.5 and 5.1.1.6.

Note - Where user-to-user information is conveyed in the SETUP message via "Keypad/Display" information elements, any user-to-user information returned in the ALERTING and/or CONNECT messages shall be contained in "Display" information elements.

If a multipoint terminal configuration exists at the user-network interface at the called side, inclusion of the "User-user information" information element in the ALERTING message is for further study; moreover if in such a case more than one CONNECT message is received, the content of the "User-user information" information element delivered to the calling user is the one in the message received from the terminal to which a CONNECT ACKNOWLEDGE message is sent as described in section 5.1.2.7.

A user facility request/indication may be included in SETUP, ALERTING or CONNECT messages to indicate that either :

i) User-to-user signalling is present in the message (Note - no user-to-user signalling is allowed in the ALERTING message for point-to-multipoint operation)

or

ii) the originator of the message has the capability to receive user-to-user signalling information.

The precise definition of the facility request requires further study. However, it should indicate the type of information element to be used for the conveyance of user-to-user information (i.e. functional or stimulus).

b) Transfer of USER INFO messages

Once the call is established, both the involved users can transfer information between themselves by transferring USER INFO messages across the user-network interface. The network provides for the transfer of such messages from the calling to the called side and vice-versa.

The USER INFO message includes as information elements the call reference, the user-user information as defined in section 3.2.30 and the more data indication. The more data indication is set by the source user to indicate to the remote user that another USER INFO message will follow, containing information belonging to the same block. The use of the more data indication is not supervised by the network.

If the user-to-user signalling facility is provided, the transfer of USER INFO messages across the calling and called user-network interfaces may be performed in the following states (see sections 2.2.1 and 2.2.2) : CALL-DELIVERED/CALL RECEIVED and ACTIVE. No more than two messages (provisional value) may be transferred in the CALL DELIVERED/CALL RECEIVED states in each direction; transfer of message in such a state in case of a multipoint terminal configuration is for further study. USER INFO messages received from the user in any other state of the call are discarded by the network and the user notified with a STATUS message with a cause "USER INFO local discard".

In any case, sending of USER INFO messages does not change the state of the call.

As described in section 3.2.30, USER INFO messages may contain a "User-user information" information element or a "Display" information element. The choice of information element should be made according to the user-to-user facility request in the SETUP message.

Note - Simple terminals may transmit user-to-user information via "Keypad" information elements contained in INFORMATION messages at any phase of a call following the generation of a SETUP message. Such user-to-user information shall be delivered to the remote user via a "Display" information element contained within a USER INFO message. The ability for the user to send a USER INFO message with the "Display" information element (to be conveyed transparently by the network) is for further study.

c) Flow control of USER INFO messages

The network will flow-control, when needed, the transfer of USER INFO messages from a user by means of a CONGESTION CONTROL message containing a "Congestion level" information element. Two indications of "Congestion level" are specified : "receive not ready" and "receive ready". On receipt of the former, the user should suspend sending USER INFO messages; on receipt of the latter, sending may recommence. After having sent a receive not ready indication, the network may discard USER INFO messages which are subsequently received and the user notified by a STATUS message with a cause "User INFO local discard" for at least the first discarded message.

The receipt of the receive ready indication by the user shall be interpreted by the user as an indication that no more than "n" USER INFO messages may be sent before another receive ready indication is received from the network. The value of "n" requires further study.

Note - Where user-to-user information has been conveyed within "Keypad" or "Display" information elements, CONGESTION CONTROL message may also contain "Display" information elements. The character sequences contained in the "Display" information elements shall be network dependent.

The network will send a receive not ready indication whenever a USER INFO message is locally discarded. The possible inclusion of additional indications in the CONGESTION CONTROL message to signify intermediate congestion levels between "receive not ready" and "receive ready" is for further study.

d) Call clearing

A "user-user information" information element with the characteristics above described may be included in the DISCONNECT, DETACH and RELEASE messages. The information contained in such an information element is transferred to the remote user in the corresponding clearing message. Such a transfer is only performed if the information is received at the local exchange of the remote user before sending a clearing message to that user; otherwise, the information is discarded.

Note - Application of flow-control procedures by the user is for further study.

5.2.3 User-to-user signalling via a temporary signalling connection

a) General characteristics

This feature allows the users to communicate by means of user-to-user signalling without setting up a circuit-switched connection. A temporary signalling connection is setup and cleared in a similar way to the control of a circuit-switched connection, as detailed in the following.

b) Call establishment

Procedures for call establishment are as described in sections 5.1.1 and 5.1.2 with the following modifications.

On call request, the SETUP message sent by the calling user will indicate "I.451 user-to-user signalling" in the bearer. Service identification information element, thereby indicating to the network that the establishment of a B-channel connection is not required. Moreover nor B-channel preference is indicated, as described in section 5.1.1.2. Similar rules apply to the SETUP message sent at the called side. Sending of call information is always performed en-bloc.

Procedures as described in § 5.2.2 apply for the inclusion of the "User-user information" information element in call establishment messages and for the handling of ALERTING and CONNECT messages.

c) Transfer of USER INFO messages

The procedures described in section 5.2.2 b) apply, where the call reference applies to the signalling connection.

d) Flow control

The procedures described in section 5.2.2 c) apply.

e) Call clearing

The procedures for clearing the signalling connection are as described in sections 5.1.3 and 5.2.2 d).

5.2.4 User-to-user signalling via a permanent signalling connection

This feature allows the users to communicate by means of user-to-user signalling without setting up a circuit-switched connection; moreover, the communication is permanently in the ACTIVE state. Thus, the only messages transferred by the users across the user-network interface are the USER INFO messages.

Procedures for transfer of USER INFO messages are as discribed in section 5.2.2 b). The value of the call reference is as specified in section 5.2.3 b).

Procedures for flow control are as specified in section 5.2.2.

5.3 Procedures for packet communications

This section is intended to explain the role of the D-channel signalling procedures in the support of packet communications in an ISDN. A complete description of terminal adaptor (TA) functions necessary for X.25 terminals support can be found in Recommendation X.31 (I.472) together with a description of ISDN-based packet handling functions.

According to the scenarios defined in Recommendation X.31 (I.472), packet communications may be accessed, using either :

a) the maximum integration scenario. In this case a packet-handling function (PH) is included within an ISDN. In this case any channel may be used for access;

b) the minimum integration scenario. In this case only a B-channel is used for access.

The procedure in sections 5.3.2 and 5.3.3 apply to the maximum integration scenario.

5.3.1 Packet switching service via B-channel

In this context, the ISDN provides a physical 64 kbit/s semi-perminent or switched channel between the appropriate PH/PSPDN port and the user terminal (TE1/TA) at the customer premises. The user terminal shall communicate with the PH/PSPDN over the B-channel using full X.25 procedures (layers 2 and 3).

In the case of semi-permanent access, the user terminal shall be dedicated to the corresponding PH function or ISDN interface port at the PSPDN (IP).

In the case of switched access, the user terminal shall first set up, via the ISDN signalling procedure, the path towards the PH/PSPDN port (layer 1 set up) before starting X.25 layer 2 and layer 3 functions.

For calls originated by the PH/PSPDN, the same considerations as above shall apply.

5.3.1.1 Elements of procedure

5.3.1.1.1 Outgoing call

1) Establishment of the circuit-mode connection (B-channel) to PH/PSPDN

a) Leased connection

The method of establishment of leased circuits is for further study.

b) Switched connection

Switched connections to a PSPDN or PH shall be established using the D-channel signalling procedures for outgoing call establishment described in section 5.1.1.

2) Packet-mode operation

Following the establishment of the connection, the user terminal shall communicate with the PSPDN or PH using full X.25 procedures (layers 2 and 3).

3) Clearing of the circuit-switched connection to the PH/PSPDN

a) Leased connection

The method of clearing of leased circuits is for further study.

b) Switched connection

The clearing of the switched connection shall be effected by using the D-channel signalling procedures for call termination described in section 5.1.3. Thus the B-channel may be cleared at any time by the user though, in general, it will be cleared following the clearing of the last virtual call over that B-channel. The circumstances in which the network shall clear the connection require further study.

5.3.1.1.2 Incoming calls

1) Establishment of the circuit-switched connection (B-channel) to TA/TE1

The B-channel to the called user shall be established by the network using the D-channel signalling procedures for incoming call establishment described in section 5.1.2. The call will be either offered to all packet-mode user equipment at the user interface or to a single user equipment identified by the TEI value of the TA/TE1 (see section 5.2.3) or by means of the ISDN sub-address.

2) Packet-mode operation

Following the establishment of the connection, the PH/PSPDN shall use X.25 procedures (layers 2 and 3) to communicate over the B-channel to the called user.

3) Clearing of the B-channel connection

See section 5.3.1.1.1.3.

5.3.1.2 Overview diagrams of signalling flow

Figures 5-1/Q.930 and 5-2/Q.930 describe the signalling message flows on the D-channel and the X.25 transmissions on the B-channel necessary to effect X.25 packet communications over the B-channel.

Note - These figures are included for explanatory purposes and do not show all X.25 frames which may be sent across the user-network interface within the B-channel (e.g. layer 2 acknowledgements of I frames and the possible use of the restart procedure).

5.3.2 Packet switching service via the D-channel

The D-channel enables ISDN user terminals to access a PH function within the ISDN by establishing a data link connection to that function which can then be used to support packet communication according to X.25 layer 3 procedures. The address of the ISDN interface over which such access is being made will be known either directly or indirectly by the PH function. The specific address of the terminal making this access shall be supplied by the layer 2 service of the D-channel access link.

The layer 2 procedures shall be in accordance with Recommendation Q.920 (I.441). The D-channel provides a semi-permanent connection for packet access since all layer 2 frames containing a packet-mode SAPI will be routed automatically between the user and PH function.

The PH function may similarly effect the establishment of data link connection over the D-channel of an ISDN interface to a user equipment capable of operating in the packet mode in order to deliver an incoming packet call. In this case, the call will be either offered to all packet-mode user equipment at the user interface or to a single user equipment specified by the TEI value in accordance with the channel selection procedures described in section 5.3.3.

A number of packet-mode user equipments can operate simultaneously over the D-channel, each using a separate layer 2 link identified by an appropriate address (see Recommendation Q.920 (I.441)) in frames transferred between the user and PH function.

5.3.2.1 Overview diagrams of message flows

Figures 5-3/Q.930 and 5-4/Q.930 describe the message flows for packet communications over the D-channel.

Note in section 5.3.1.2 applies.

5.3.3 Packet-switching service with channel selection

The choice of which channel to use for the delivery of a new incoming packet call shall be made by the PH according to certain criteria (see Recommendation X.31 (I.472), section 3.2.2). In the most general case, new incoming packet calls may be indicated to the ISDN customer via the point-to-multipoint call offering procedures. The call offering procedure is performed using the layer 3 messages and procedures of section 5.1.2 and these layer 3 messages may be carried in data link layer frames with the Service Access Point Identifier (SAPI) indicating either packet data (p) or signalling (s) information (see Recommendation Q.920 (I.441)). The choice of which of these two alternative procedures to be used is a network option, e.g., which may be specified at subscription time or may be dependent on the channel being offered for the new incoming packet call in the call offering procedure. The operation of these two alternative procedures is as follows :

a) Networks using SAPI = "s" at data link layer

In this case the call offering procedure is integrated into the circuit-switched call control procedures with the channel selection being accomplished by means of the channel negotiation procedures if offered as a network option (see section 5.1.2.2). However, in the case where the TA/TE1 requests the new incoming packet call on either a B-channel already established for packet-mode calls or on the D-channel, the network will terminate the layer 3 procedures after the channel negotiation phase using the RELEASE message.

b) Networks using SAPI = "p" at data link layer

In this case, the call offering procedure takes the form of an enquiry/response interaction at layer 3 which precedes any procedures for circuit or packet-switched call control. The call offering procedure uses identical messages to the SET-UP, SET-UP ACK, RELEASE and RELEASE ACK messages described in section 5. The channel selection function is performed using the layer 3 channel negotiation procedures of section 5.1.2.2 if offered as a network option. The four messages of the call offering procedure are conveyed using the Unacknowledged Information Transfer Service at data link layer. If the TA requests the use of a free B-channel then following the call offering procedure, the network shall initiate the establishment of a B-channel to the selected TA/TE1 by using the procedures described in section 5.1.2. In this

case, the called TA/TE1 shall be identified by means of the TEI value of the TA/TE1 which is returned with the SET-UP ACK response to the SET-UP message during the call offering sequence. Alternatively, the TA/TE1 may be identified by a sub-address in which case the establishment of a B-channel to the selected TA/TE1 may be achieved using the point-to-multipoint incoming circuit-switched call procedures. If the TA/TE1 requests the incoming packet call on either a B-channel already established for packet-mode calls or on the D-channel, then no further D-channel signalling (following the call offering procedure) is required before the X.25 procedures begin.

According to the extent of addressing, sub-addressing and bearer service indication information provided by the calling terminal, these procedures will allow the call to be offered to a subset of the terminal population at the ISDN address or to a specific interface at reference points S or T.

Apart from this general approach to incoming call offering, in some circumstances and optional (for a period for which the facility is subscribed), the service characteristics for a particular ISDN address may be registered at the PH such that the network may choose the access channel for a particular incoming call packet. Furthermore, in such cases, it shall also be possible to route an incoming call packet to the called terminal over an established B-channel connection or D-channel link without the need for any preceding D-channel signalling. Also some networks may not provide an option for channel negotiation. In this manner the particular approach to incoming call routing may be tailored to meet the particular requirements of the network and the user.

Where a number of ISDN lines form a "Hunt Group", successive incoming packet calls may be routed on different lines in accordance with the line selection algorithm associated with that group. Each call will be offered on the chosen line using either the general call offering procedure or specific incoming call routing as appropriate.

The channel selection procedure for incoming calls is independent of the type of channel selected at the calling end. In this respect, any combination of channel type used at each end is possible.

The procedures for channel selection are shown in Figures 5-5/Q.930 and 5-6/Q.930.

Key to the Figures 5-1/Q.930 through 5.6/Q.930

D-channel signalling messages

[ ] Layer 3
C - CONNECT
CA - CONNECT ACKNOWLEDGE
CC - CALL CONNECTED
D - DISCONNECT
R - RELEASE
IC - INCOMING CALL
S - SET-UP
SA - SET-UP ACKNOWLEDGE
CS - CALL SENT
RA - RELEASE ACKNOWLEDGE

X.25 level 3 messages

Any layer 3 message preceeded by X.25 indicates an X.25 layer 3 packet e.g. ∠ X.25 CR ⁄ = X.25 Call Request packet.

CA - CALL ACCEPTED
CC - CALL CONNECTED
CLC - CLEAR CONFIRMATION
CLI - CLEAR INDICATION
CLR - CLEAR REQUEST
CR - CALL REQUEST
IC - INCOMING CALL

Layer 2 frames

() - Layer 2
GTEI - Group TEI
A,B - X.25 layer 2 addresses (includes command and response)
Layer 2 addresses marked (X, p) indicates that the SAPI element of the frame address is coded as for packet type information as described in Recommendation Q.920 (I.441). Layer 2 addresses marked (X, s) refer to signalling type information

SABM - Set Asynchronous Balance Mode frame
UA - Unnumbered Acknowledgement frame
UI - Unnumbered Information frame (i.e. using unacknowledged information transfer service at data link layer)
I - Information frame
DISC - Disconnect frame

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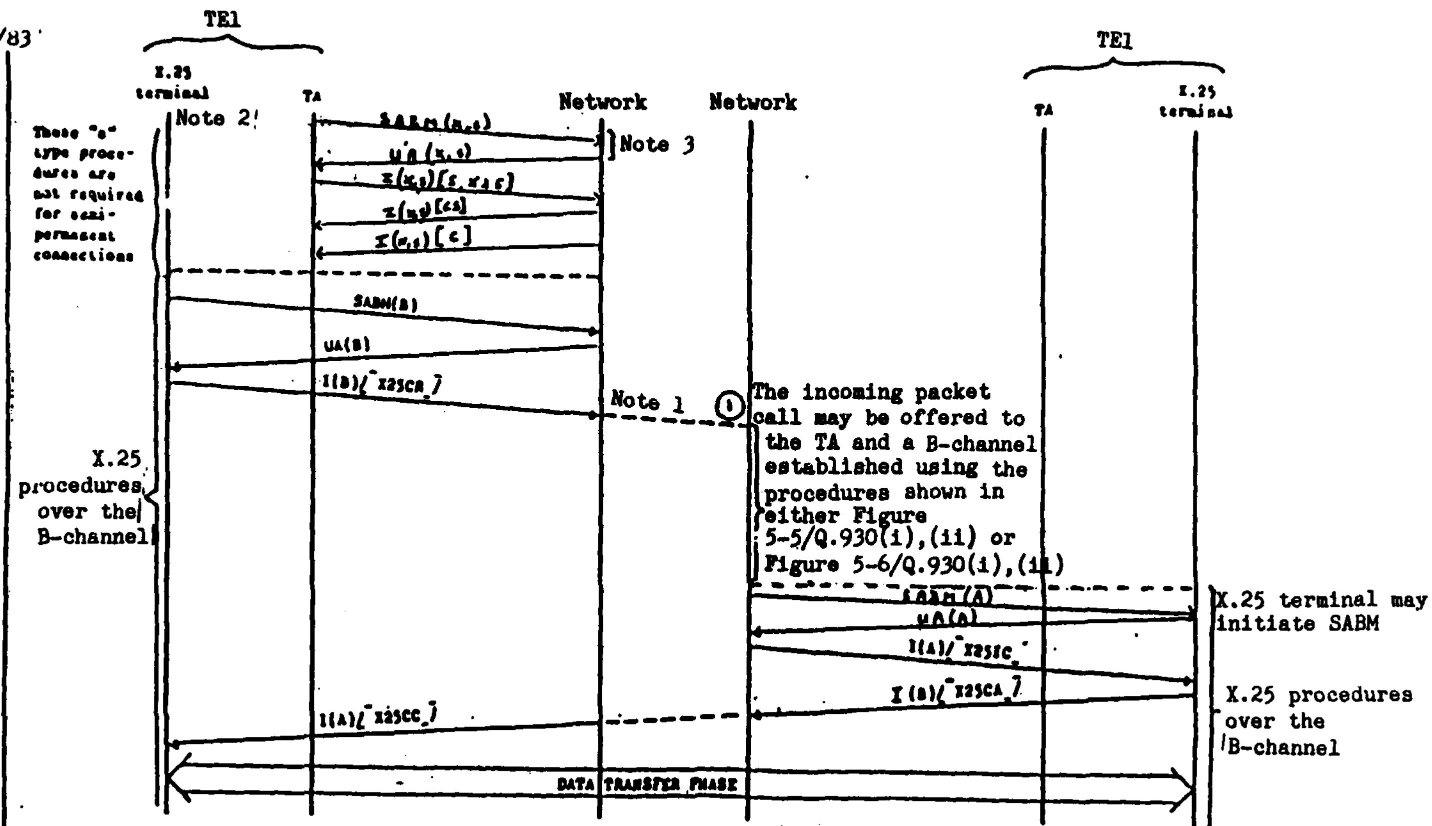

Note 1 - When the called side establishes the call using D-channel access, the message sequence will continue as from point 3 in Figure 5-3/Q.930.

Note 2 - When the calling side establishes the call using D-channel access, the message sequence on the calling side will be in accordance with the calling side of Figure 5-3/Q.930.

Note 3 - If "s" link is not already established.

FIGURE 5-1/Q.930

Message sequence for the B-channel access, first virtual call set-up in the maximum integration scenario

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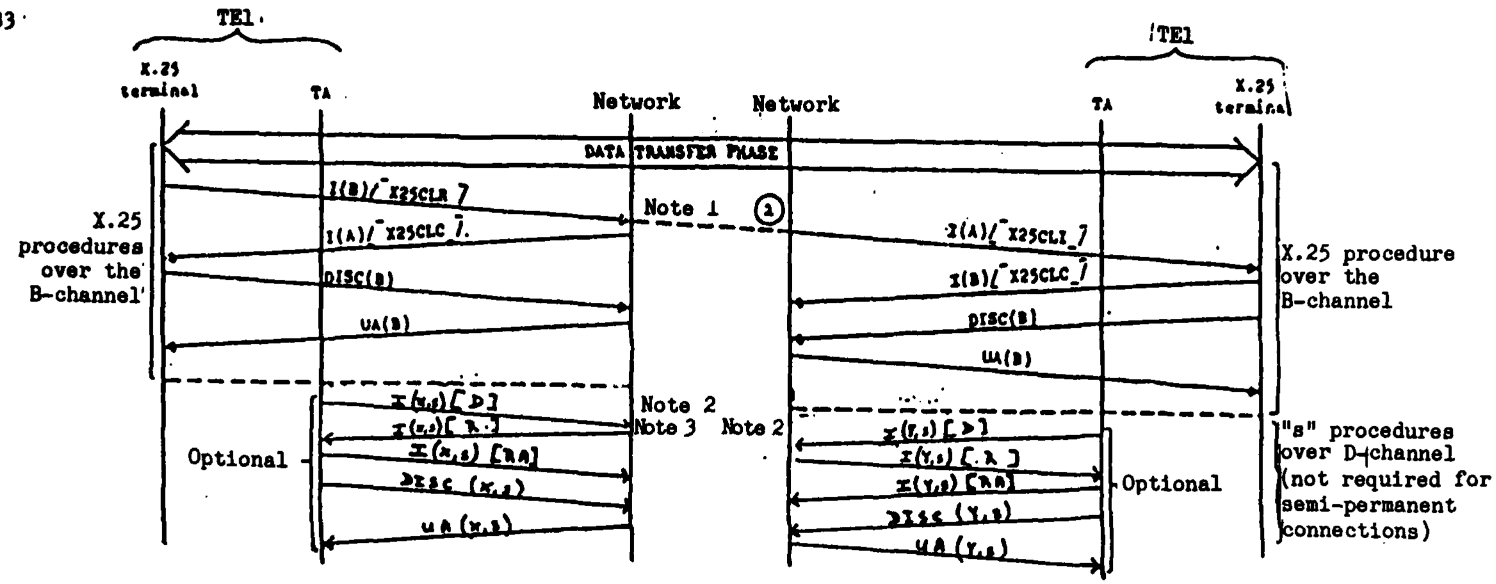


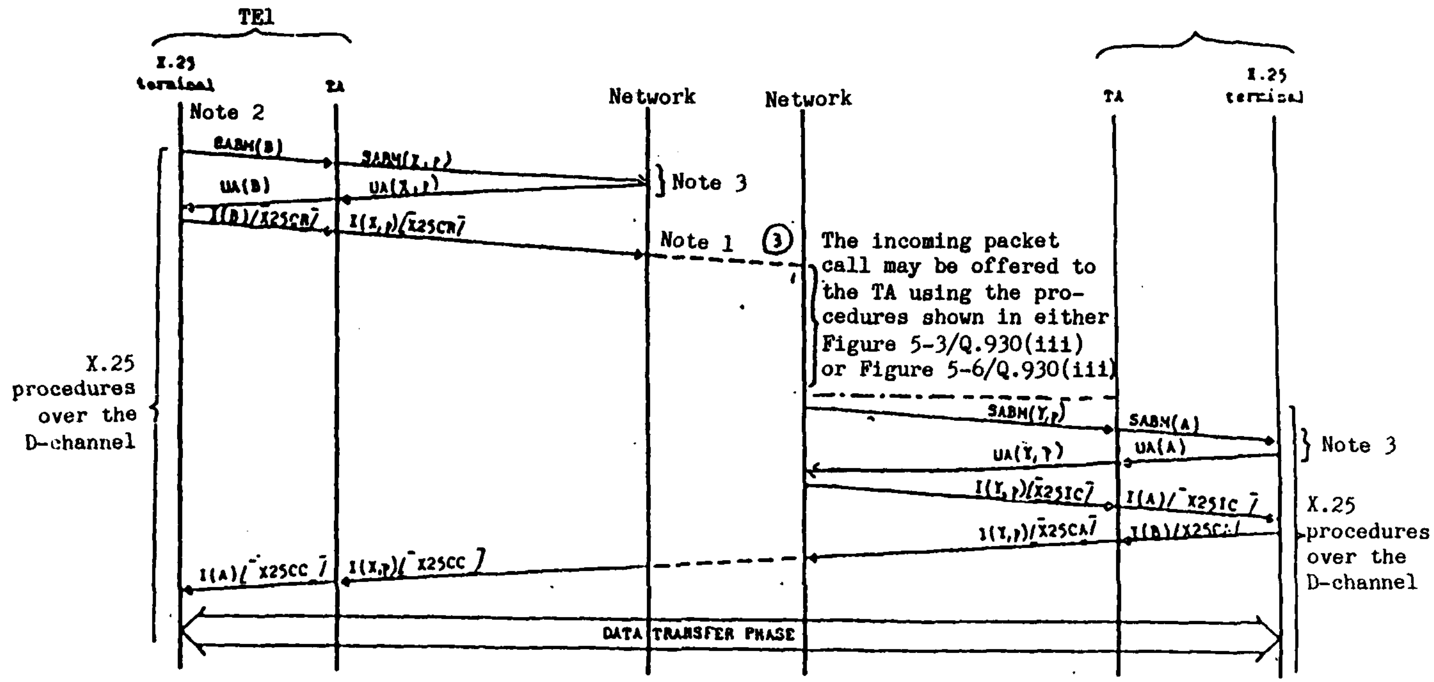
Note 1 - When the cleared side has set-up the call using D-channel access, the message sequence at the cleared side will be as from point 4 in Figure 5-4/Q.930.

Note 2 - Clearing of the B-channel may be initiated by the network.

Note 3 - The full circuit-switched clearing procedures in § 5.1.3 shall apply. Only the DISCONNECT/RELEASE message interchange has been shown for simplicity.

FIGURE 5-2/Q.930

Message sequence for the B-channel access, last virtual call clearing



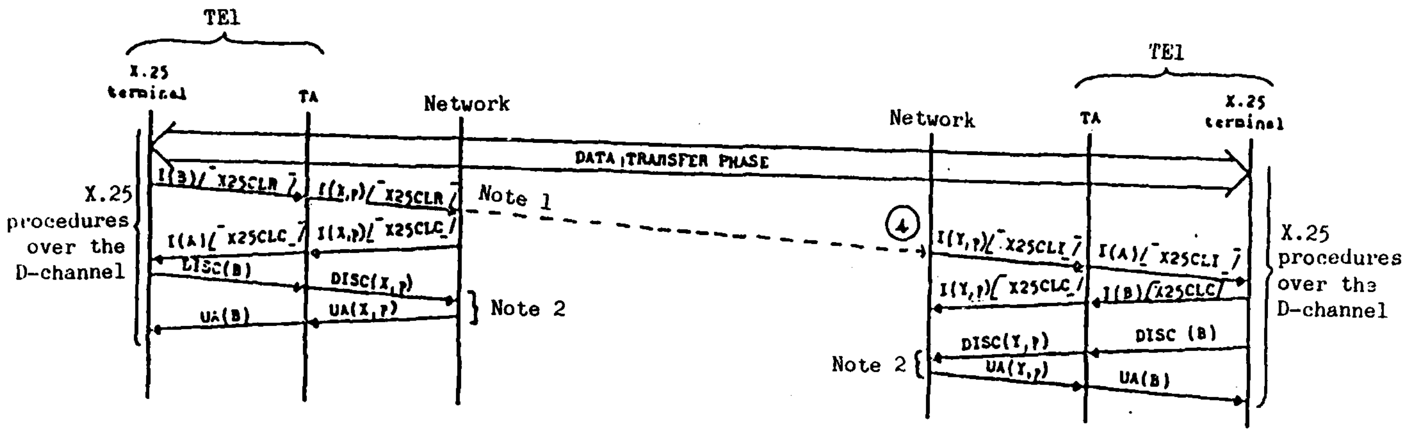
Note 1 - When the called side establishes the call using B-channel access, the message sequence will continue as from point 1 in Figure 5-1/Q.930.

Note 2 - When the calling side establishes the call using B-channel access, the message sequence at the calling side will be in accordance with the calling side of Figure 5-1/Q.930.

Note 3 - If "p" link is not already established.

FIGURE 5-3/Q.930

Message sequence for D-channel access - virtual call set-up



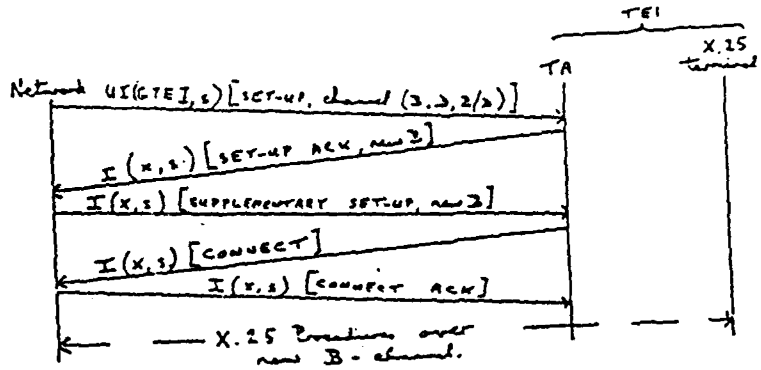
Note 1 - When the cleared side has set-up the call using B-channel access, the message sequence at the cleared side will be as from point 2 in Figure 5-1/Q.930.

Note 2 - This sequence is only required if the X.25 DTE does not wish to continue with further packet communications.

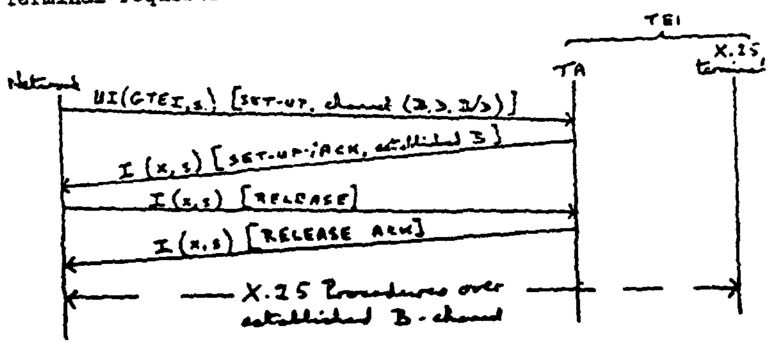
FIGURE 5-4/Q.930

Message sequence for D-channel access - last virtual call clearing

(i) Terminal requests call on a new B-channel



(ii) Terminal requests call on an established B-channel



(iii) Terminal requests call on the D-channel

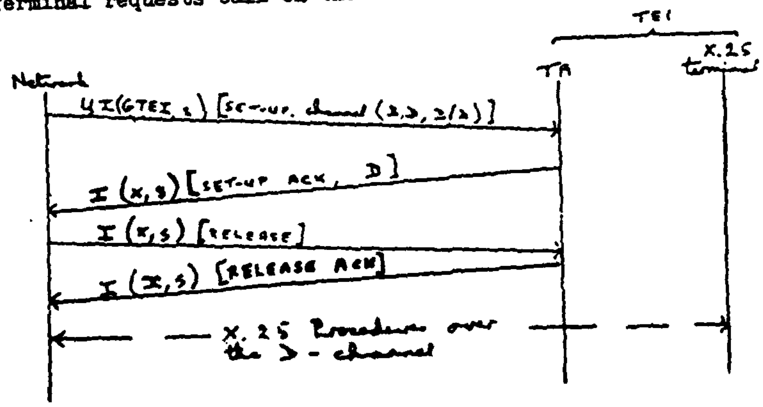
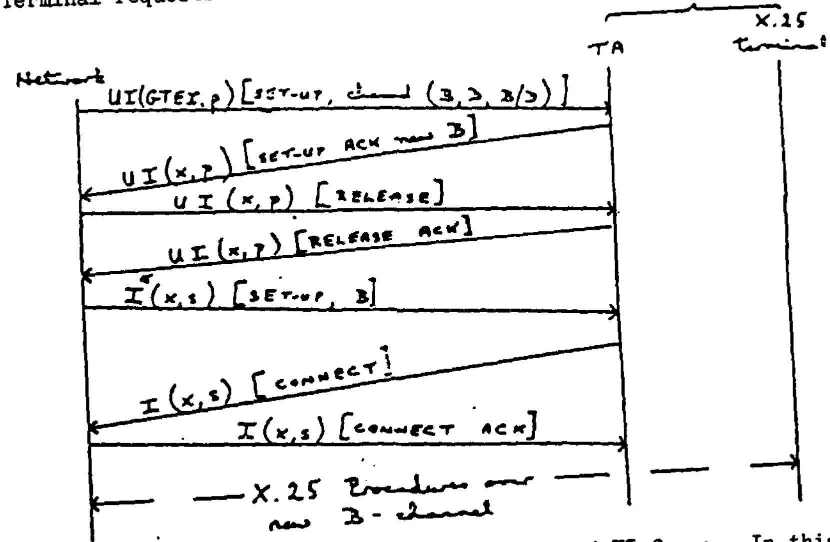


FIGURE 5-5/Q.930

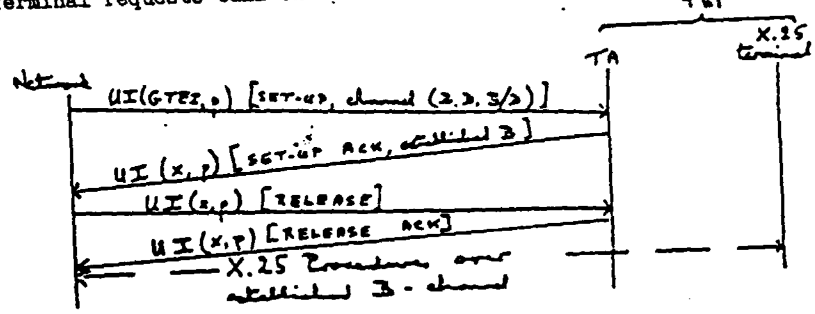
Incoming packet call offering procedure using "s" type signalling

(i) Terminal requests call on a new B-channel



* The SETUP message may be sent in a globally addressed UI frame. In this case the TA allocated the incoming packet call might, if required, be identified by its sub-address.

(ii) Terminal requests call on an established B-channel



(iii) Terminal requests call on the D-channel

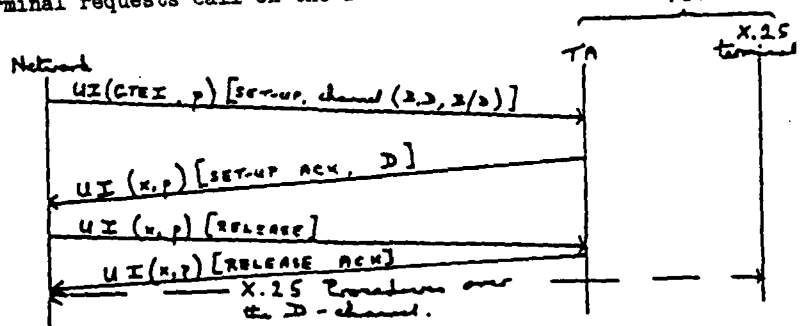


FIGURE 5-6/Q.930

Incoming packet call offering procedure using "p" type signalling

6. Application of circuit-switched call control procedures to terminals operating in a stimulus mode

This section describes how the circuit-switched call control procedures of § 5 may be used by an ISDN terminal operating in stimulus mode to establish a simple call.

For explanatory purposes, stimulus mode terminals have been classified in this section into the following types :

- Type 1 terminals for which each layer 3 endpoint has a unique data link layer address (i.e. only one B-channel may be connected at a time per data link layer address).

- Type 2 terminals for which multiple layer 3 endpoints may be associated with a single data link layer address (i.e. multiple B-channels may be connected per data link address).

Thus the procedures of § 5 may be simplified for Type 1 terminals with respect to the use of the call reference. In this respect, the data link layer address provides a unique call identity and Type 1 terminals need only include a dummy call reference in all signalling messages other than in the first response to a SETUP message (see section 6.2). Type 2 terminals are required to general a call reference in accordance with the procedures of section 5.

Signalling messages sent by stimulus mode terminals to the network are generated as a direct result of actions by the terminal user (e.g. handset lifted) and in general do little more than describe the event which has taken place at the man-machine interface. Similarly signalling messages sent by the network to terminals operating in the stimulus mode contain explicit instructions regarding the operations to be performed by the terminal (e.g. connect B-channel, start alterting, etc.).

Stimulus mode terminals are not expected to maintain a record of the state of any call which is currently supported since they have a master-slave relationship with the network. However, stimulus mode terminals are expected to retain the following information :

1) Whether or not the terminal is currently alerting (Note - this information is required to determine the correct message to be generated when the handset is lifted i.e. SETUP or CONNECT).

2) The current condition of the switchhook i.e. on or off (Note - this information is required to determine how to respond to a SETUP message).

The possible enhancement of these procedures to support additional capabilities such as multi-line or switchhookless operation (see Appendix 1) is for further study.

The following sections describe the detailed application of the circuit-switched call control procedures to Type 1 stimulus mode terminals. For Type 2 terminals, the procedures are identical except that call reference is generated in accordance with the procedures of § 5. Table 6-1 summarizes the principle operations whilst Figures 6-1, 6-2 and 6-3 show the information flows for a simple call.

6.1 Procedures for call establishment at the originating exchange

6.1.1 Call request

The call is initiated by activating the switchhook of the originating terminal, which then generates a SETUP message with a dummy call reference. This message must contain a Bearer Service Identification Information Element to inform the network of the type of call being requested and may contain a Switchhook information element. The network sends back to the user either a SETUP ACKNOWLEDGE or a CALL SENT message indicating which B-channel is to be used for the call (§ 5.1.1.1).

6.1.2 Call information sending

If there is no Keypad information element in the SETUP message, the network assumes that overlap procedure is used for sending the call information. The SETUP ACKNOWLEDGE message will contain an information element which may cause the terminal to initiate the proper prompt (e.g. dial tone, screen message) indicating that dialling can start. The dial digits are sent as Keypad information element in INFORMATION messages. When the network receives the first INFORMATION message containing keypad information element it sends an INFORMATION message to the terminal instructing it to stop the local prompt. The network may optionally acknowledge each message by sending an INFORMATION message with a Keypad echo information element. The Network determines that dialling has finished either by analysis of the digits or by receipt of an end of dialling indication as defined by the local network procedures (e.g. a # character).

An INFORMATION message may also contain the called party address en-bloc, as Keypad information element; this is mainly applicable when the user invokes a dialling facility (e.g. abbreviated address stored in the terminal, last dialled number).

If the SETUP message contains sufficient Keypad information for call establishment, then en-bloc procedure should be assumed. The network then sends a CALL SENT message to the terminal, containing the B-channel to be used.

6.1.3 Call confirmation

When the terminal has received the CALL SENT message, it may give a local call progress indication (tone, screen message). When the originating exchange receives an indication that the terminating exchange has received its request for a call set up, it sends an ALERTING message to the calling terminal. The ALERTING message may contain network dependent optional stimulus elements. The terminal then stops the possibly locally generated call progress indication (tone or other user indication), and may turn on a local indication of the alterting condition at the far end.

6.1.4 Call connected

The originating exchange sends a CONNECT message to the calling terminal when it gets an indication that the call is accepted and answered at the remote end. This message may also contain Display information element provided by the network (e.g. charging rate, address of the connected terminal). Upon receipt of this message, the terminal must turn off its possible local indication of the alerting condition at the far end.

6.2 Procedure for call establishment at the destination exchange

The network will send a SETUP message containing at least the call reference, a bearer service identification and the B-channel specification. The message may also contain optionally the signal information element Alerting-on.

The terminal checks the bearer service identification and, if not compatible, discards the complete message.

If the SETUP-message contains a Display information element, the associated IA5 characters shall be displayed to the user. Any Signal information element(s) will also be acted upon in the normal manner.

If the terminal is able to provide the service indicated, it should return an ALERTING message or directly a CONNECT message. This message will include the call reference chosen by the network and the Terminal capabilities information element. It may display any Display information contained in the SETUP message and may start alerting in response to the signal information element (Alerting-on).

All other information elements are to be ignored. There will be no negotiation of B-channels.

On an optional basis, the network may choose not to instruct the terminal to alert until after it has been informed of the terminals capabilities. In this case, the information element signal (Alerting-on) is not contained in the SETUP message. Specific alerting instructions are sent in an INFORMATION méssage after receipt of the ALERTING message.

When the terminal goes "off hook" a CONNECT message is sent to the network. This message must contain the dummy value of the call reference and may contain the Switchhook information element.

If the terminal responds to a SETUP message with a CONNECT message, it shall include the original call reference (as chosen by the network) and the Terminal capabilities information element.

The network sends a CONNECT ACKNOWLEDGE message including the original call reference (the one in SETUP), the B-channel specification and the Signal information element (Alerting-off). The terminal then connects to the B-channel indicated.

6.3 Procedures for user-to-user signalling

The procedures described in § 5.2 should be applied to stimulus mode terminal operation in the following manner :

a) SETUP messages originated by a terminal should contain a user-to-user facility request indicating that stimulus mode operation is required;

b) for calls in which the above facility is requested, user-to-user information should be conveyed in the following manner :

   1) via Keypad information elements in the SETUP message generated by a stimulus mode terminal,

2) via Display information elements in the SETUP message sent to the called terminal,

3) via Keypad information elements in INFORMATION messages generated by a terminal (Note : this information will be delivered to the remote terminal via Display elements within USERINFO messages),

4) via Display information elements in ALERTING, CONNECT, USER INFO, DISCONNECT or RELEASE messages.

TABLE 6-1/Q.930

Stimulus mode terminal operation

User action	Message generated by terminal operating in the stimulus mode
*"Lift handset" when terminal is not ringing	SETUP, [Call reference, SI] (Signal off-hook) Notes 1. For simple terminals only capable of terminating one B-channel at a time, a dummy call reference (which is reserved exclusively for this type of terminal) shall be used. 2. If the terminal can only make/accept calls on a single B-channel, then that B-channel identity will be included in the SETUP message. 3. Any information keyed in by the user while the handset is on-hook will also be sent in the SETUP message as Keypad information when the handset is lifted.
*"Lift handset" when terminal is alerting	CONNECT, [Call reference] (Signal off-hook) Notes 1. See Note 1 above on call reference. 2. The terminal is assumed to be aware that it is alerting prior to the off-hook condition.
*"Handset replaced"	DISCONNECT [Call reference] Notes 1. See Note 1 above on call reference.
Key depressed	INFORMATION [Call reference] (Keypad information) Notes 1. See Note 1 above on call reference. 2. The Keypad information element contains the corresponding IA5 character of the key depressed.

* Or equivalent action.

[x] Mandatory information element.

(y) Optional information element.

User action	Message generated by terminal operating in the stimulus mode
Special keys/pre-programmed keys (for supplementary services)	These keys generate the INFORMATION message containing : a) appropriate supplementary service stimulus information element, see § 6.5, b) Keypad information element. <u>Notes</u> 1. Both messages will have a call reference set according to the rules described above. 2. In the case of b), the Keypad information element will contain the sequence of IA5 characters which the user would have had to key-in to request the supplementary facility if the special key had not been implemented.
Message received	**Terminal action**
SETUP	Perform simple compatibility checking using the bearer service identification and channel identification information elements. If the compatibility check is positive, the terminal will return an ALERTING message using the call reference contained in the SETUP message.
SETUP ACKNOWLEDGE, CALL SENT, CONNECT ACKNOWLEDGE	The terminal attaches to the B-channel indicated in the message.
INFORMATION (Display)	The IA5 information contained in the Display information element is displayed by the terminal.
ALERTING	May be used to provide an audible or visual indication that far end alerting has begun.
CONNECT	May be used to provide audible or visual indication that far end connect has occurred.
DISCONNECT	No action taken. DISCONNECT may be used to provide an indication of call cleared.
RELEASE	Disconnect from B-channel and send RELEASE ACKNOWLEDGE.
Any message	The terminal will take the appropriate action to Display and Signal information elements which may be contained in any message type.
INFORMATION (Stimulus information elements)	The terminal will take the specific action indicated in the stimulus information element. See § 6.5.

6.4 Procedures for call clearing

Call clearing procedures have been simplified for the stimulus mode terminals. Clearing procedures are described in §§ 6.4.1 and 6.4.2 and shown in Figure 7-3.

6.4.1 Call clearing by the terminal

The user initiates call clearing by replacing the switchhook (or equivalent). The user equipment generates a DISCONNECT message. The network responds to the DISCONNECT message by sending a RELEASE message to the user. Upon receipt of the RELEASE message, the terminal detaches from the B-channel and generates a RELEASE ACKNOWLEDGEMENT in accordance with the procedures in § 5.1.3.

6.4.2 Call clearing by the network

The network initiates clearing by sending a DISCONNECT message to the user. When the user replaces the switchhook (or equivalent), a DISCONNECT message is sent to the network. After the terminal generates the DISCONNECT message, the procedures are as described in § 6.4.1. If, after receipt of a DISCONNECT message, the user does not replace the switchhook within the prescribed period (T305), the procedures in § 5.1.3.2 are invoked.

6.5 Stimulus information elements

A provisional list of information elements and their definitions is contained in this section. These information elements may be used for stimulus signalling. The precise meaning and application of those elements which are not described in §§ 5 and 6.1 through 6.4 of this Recommendation is for further study.

Coding space for additional stimulus information elements has been reserved in § 4. Possible assignment of the reserved codes to the stimulus information elements in this section which do not appear in §§ 5 or 6.1 through 6.4 is for further study. The information elements which have been coded in § 4 are marked with *.

6.5.1 Information elements from terminal to network

6.5.1.1 Charging method selection information element

This information element from the terminal to the network indicates the billing method (reverse charging, third number etc.) to be used for a given call.

6.5.1.2 Bearer service indication information element

This information element from the terminal to the network specifies that the call is requesting a service specified by the information contained in this information element.

6.5.1.3 Bearer service acknowledge information element

This information element from the terminal to the network reports whether the terminal's capabilities match the bearer service identification in the SETUP message. This indication can take one of three forms :

1) terminal's capabilities match the bearer service identification;

2) terminal's capabilities do not match the bearer service identification;

3) terminal's capabilities match the bearer service identification and terminal can accept the call.

The third response is optional for intelligent terminals. The network must be capable of interfacing with terminals which do not provide information on whether they can accept the present call.

6.5.1.4 Call waiting accepted information element

This information element is sent from the terminal to the network to indicate that the user wishes to place his current call on hold, and accept the incoming call which generated the signal information element (Call waiting tone on).

6.5.1.5 Charge advice information element

This information element from the terminal to the network requests charge information at the completion of a given call.

6.5.1.6 Conference information element

This information element from the terminal to the network requests a conference call. After receipt of the conference information element, the network should expect to receive a Keypad information element containing the address of the connection to be added.

6.5.1.7 Closed user group selection information element

This information element is sent from the terminal to the network to indicate that a call is to be placed to a closed user group. This information element will be followed by a Keypad information element, containing the identity of the closed user group.

6.5.1.8 Feature activation information element

This information element from the terminal to the network is used to convey requests for features that are not included in the fixed function signal set. A feature activation information element is assignable to any function, allowing flexibility in offering features for stimulus mode terminals. The Feature activation information element can be used to provide supplementary features on a system specific or national option basis.

6.5.1.9 Hold information element

This information element from the terminal to the network is a request to place the current call on hold. Recovery from Hold is for further study.

6.5.1.10 Keypad information element

This information element from the terminal to the network is used to convey information from the terminal's keypad.

6.5.1.11 Resume information element

The use of this information element is as defined in § 5.1.4.

6.5.1.12 Transit network select information element

This information element from the terminal to the network indicates the transit network chosen by the user to provide transmission facilities for use with a given call.

6.5.1.13 Self-test response information element

This information element from the terminal to the network is in response to the Self-test inquiry signal. It enables the terminal to report the results of its self-test to the network. The nature of the terminal self test, if provided, is for further study. If no self-testing capability is provided by the terminal it will so indicate via this information element.

6.5.1.14 Terminal capabilities information element

This information element is sent to the network as part of the ALERTING or CONNECT message in response to the functional SETUP message. It indicates to the network that it is a stimulus mode terminal.

6.5.1.15 Suspend information element

The use of this information element is defined in § 5.1.4.

6.5.1.16 Switchhook information element

This information element from the terminal to the network indicates a change in the switchhook state.

6.5.1.17 Switchhook response information element

This information element from the terminal to the network reports the switchhook status as requested by a Switchhook inquiry information element from the network.

6.5.1.18 Terminal capabilities response element

This information element from the terminal to the network is a response to the Terminal capabilities inquiry information element. It contains a list of the bearer services the terminal is capable of handling.

6.5.1.19 Transfer information element

This information element from the terminal to the network is a request to transfer the current call. After receiving this information element, the network should expect to receive a Keypad information element containing the address where the call is to be transferred.

6.5.2 Information elements from network to terminal

6.5.2.1 Bearer service identification information element

This information from the network to the terminal informs the terminal of the bearer service associated with an incoming call.

6.5.2.2 Display information element

This information element from the network to the terminal contains information to be displayed on the terminal's display. The message contains IA5 characters. Escape sequences for screen controls (cursor, clearing screen, etc.) are for further study.

6.5.2.3 Feature indication information element

This information element from the network to the terminal causes the terminal to activate an indicator associated with the feature activation function. An example of a Feature indication is the lighting of a lamp in response to the pressing of a feature button.

6.5.2.4 Keypad echo information element

This information element from the network to the terminal acknowledges receipt of a Keypad information element. This information element is used to provide visual or audible feedback to the terminal user to indicate that address digits or feature codes have been received by the network. It does not need to be interpreted by the terminal.

6.5.2.5 Reset information element

This information element from the network to the terminal causes the terminal to be reinitialized. The terminal resets layer three signal processing and deactivates all indicators.

6.5.2.6 Self-test inquiry information element

This information element from the network to the terminal causes the terminal to perform a self-test.

6.5.2.7 Signal information element

This information element from the network to the terminal tells the terminal to generate alerting signals, call progress tones or other indications informing the user of an incoming call or about the current status of a call. The data field of this information element provides for distinctive alerting signals allowing, for example, use of different ringing patterns to indicate an on-premises versus an off-premises call. Call progress indications are : dial tone, ringing, busy, reorder, confirmation of a request, call answered, call waiting, and off-hook warning.

6.5.2.8 Switchhook inquiry information element

This information element from the network to the terminal requests the status of the terminal's switchhook.

6.5.2.9 Terminal capability inquiry information element

This information element from the network to the terminal inquires as to the capabilities of the terminal. The terminal responds with the Terminal capability response information element which reports the bearer services that the terminal can handle.

```
                          Originating              Originating   Terminating                Called
                          terminal                 network       network                    terminal
                             |                        |             |                          |
Terminal sends               |        SETUP           |             |                          |
call information             |----------------------->|             |                          |
en bloc.    ---->            |[BSI,Ref<dummy†>](Switch-|            |                          |
(see Figure 7-2/Q.930        | hook<Off-hook>) (KEYPAD or           |                          |
for overlap                  | CALL INFORMATION) Ø    |             |                          |
procedures)                  |[Terminal capabilities] |             |                          |
                             |      CALL SENT         |             |                          |
Terminal                     |<-----------------------|             |                          |
connects to                  |[Ref<dummy†>, B-channel]|             |  SETUP(see note 6)       |
B-channel                    |(DISPLAY)               |             |------------------------->|Terminal verifies
                             |                        |             | [SI,Ref<x>,B-channel]    |compatibility with SI
                             |                        |             | (Signal<ALERTING-ON>)    |
                             |                        |             | (CALL INFORMATION, DISPLAY)
                             |                        |             |                          |
                             |                        |             | ALERTING (see Note 8(a)) |
KEY                          |       ALERTING         |             |<-------------------------|Subject to compatibility,
---                          |<-----------------------|             |[Ref<x>,*Terminal capabili-|terminal responds.
                             |  [Ref<dummy†>] (see Note             | ties] INFO (see Note 8(b))
[ x ] mandatory information  |  3(a))                 |             |                          |
      element                |                        |             |[Ref<x>](Signal Alerting- |
                             |       CONNECT          |             | ON>)  CONNECT            |
( y ) optional information   |<-----------------------|             |<-------------------------|Terminal goes
      element                |[Ref<dummy†>] (DISPLAY, |             | [Ref<dummy†>](Switchhook |OFF HOOK
                             | CALL INFORMATION)      |             | <Off-hook>)              |
(See Note 1)                 | (see Note 3(b))        |             |  CONNECT ACKNOWLEDGE     |
                             |                        |             |------------------------->|Terminal connects
                             |                        |             |[Ref<x>, B-channel]       |to B-channel
                             |                        |             |                          |
```

† See Note 1(b).

* Included in the first response to SETUP.

Ø CALL INFORMATION is taken to mean addressing and facility information necessary for call establishment. If the network determines that insufficient information is present in SETUP the overlap procedures would be assured.

FIGURE 7-1/Q.930

Functional procedures with stimulus information elements for basic call establishment

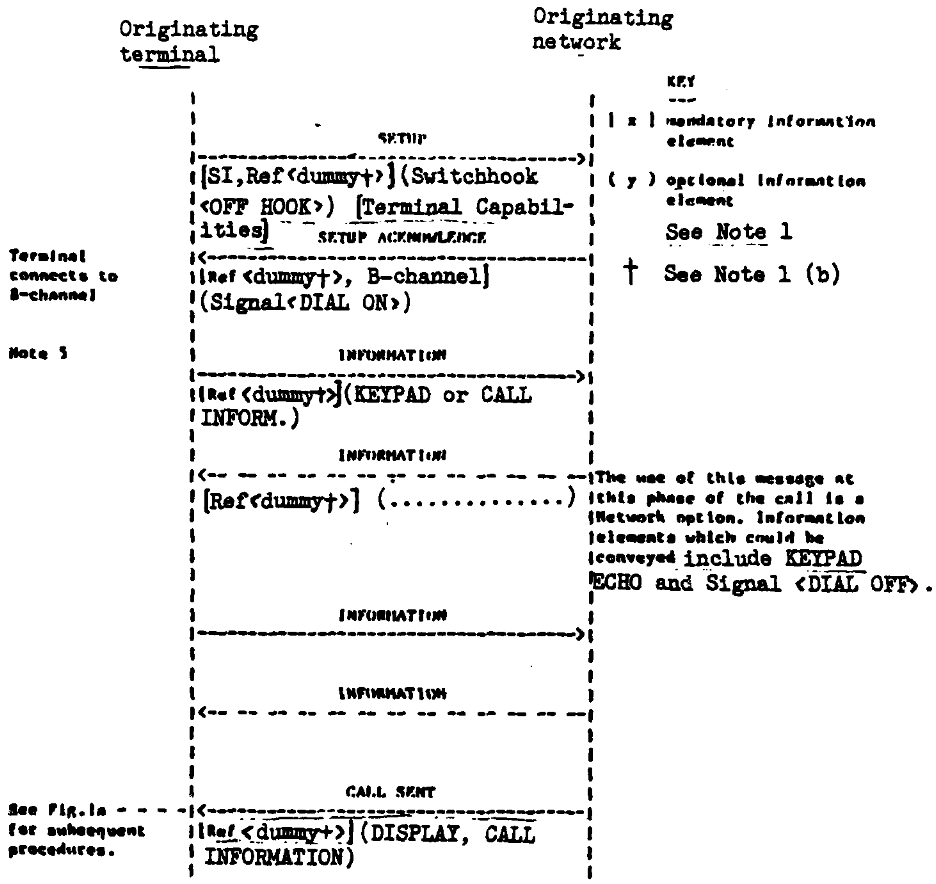
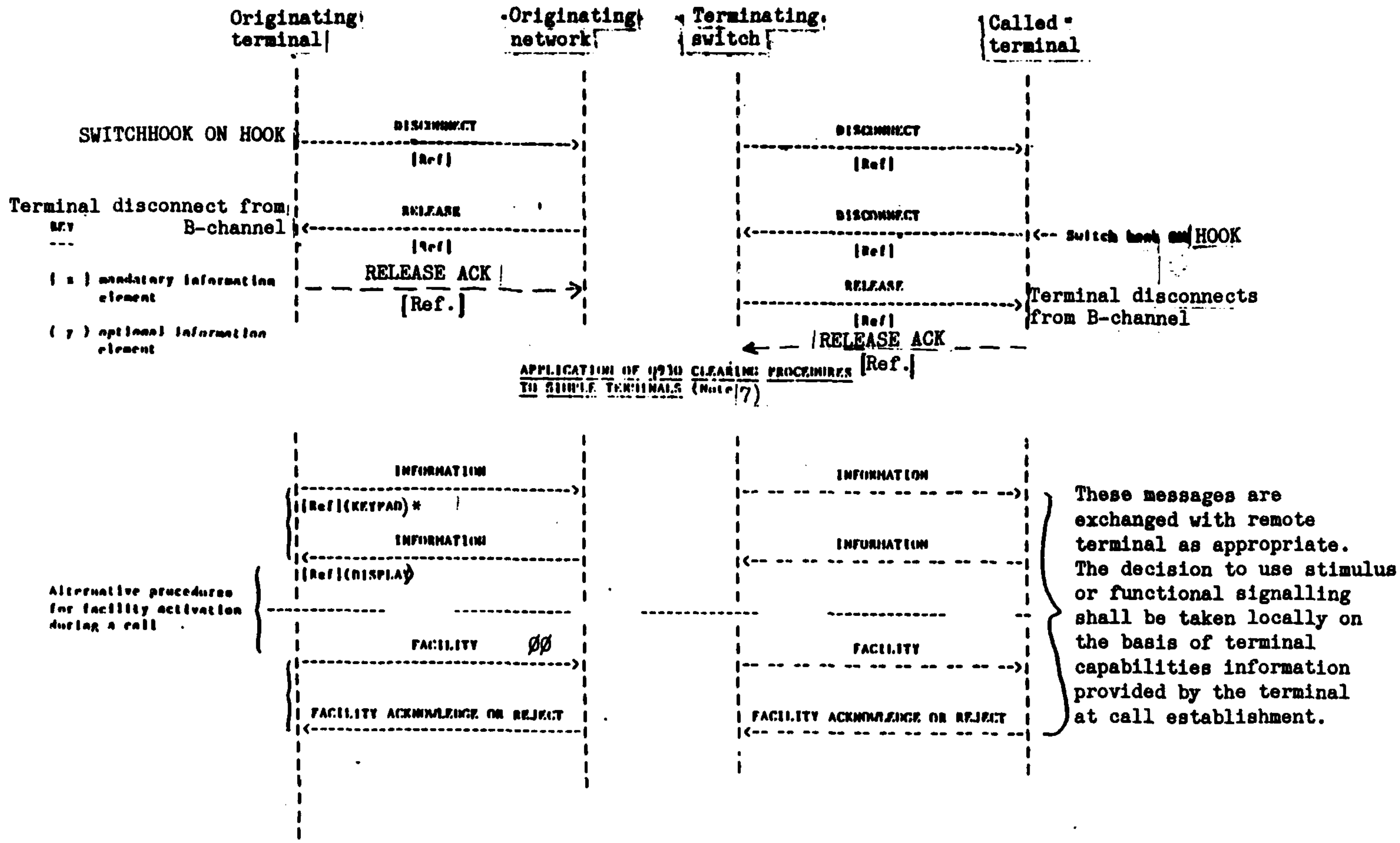


FIGURE 7-2/Q.930

Overlap procedures for basic call establishment



* Other stimulus information elements may also be used.

ØØ If the FACILITY message contains a dummy call reference the network may send an INFORMATION message to supplement the FACILITY ACKNOWLEDGE/REJECT message.

FIGURE 7-3/Q.920

Clearing and facility activation/deactivation during a call

Notes to Figures 7-1, 7-2 and 7-3/Q.930

1.(a) The mandatory and optional elements shown in each message are those necessary for simple terminals. Other information elements would also be included in accordance with Q.930(I.451) but could be ignored by the simple terminal.

(b) The "dummy" call reference is used for Type 1 terminals only. Type 2 terminals use the call reference in the usual Q.930(I.451) manner.

2. It is intended that the message elements which are essential for simple terminal operation should be included at the beginning of each message.

3.(a) The information element "Signal<Ringing on>" may be optionally included in this message. It is envisaged that this information element would not be used for Public Network access but could be employed for terminal to PBX signalling.

(b) If the information element "Signal<Ringing-on>" was sent in the ALERTING message, then "Signal<Ringing-off>" should be included in the CONNECT message.

4. A Display information element may be included in any message sent by the network to the terminal. The nature of the information to be displayed is a network dependent matter.

5. INFORMATION messages may be sent by the network or terminal at any time in a call. This message may be used to convey information elements such as Keypad (terminal to network), Signal, Display (network to terminal).

6. The information element "Signal<Alerting-on>" may be included in the SETUP message to indicate a particular alerting pattern. The alerting action is autonomously terminated by the terminal when it goes off-hook and sends a CONNECT message.

7. In clearing procedures in Figure 7-3/Q.920, the sending of a DETACH message is not precluded.

8.(a) If the SETUP message included the information element "Signal<Alerting-on>", then the terminal will generate a local alerting signal in conjunction with returning the ALERTING message.

(b) If the SETUP message did not include the information element "Signal<Alerting-on>", then the terminal will simply return the ALERTING message with the information element "Terminal capabilities" to inform the network that it is a simple terminal. The network may instruct the terminal to begin alerting by sending the information element "Signal<Alerting-on>" in the INFORMATION message.

Appendix : 1

APPENDIX I

This Appendix is provided only for information. It shows only one possibility of solving the problem hereunder mentioned. Further study is required to evaluate all the implications.

An example modification to stimulus mode call control procedures to simplify terminal requirements and provide for enhanced capabilities such as multi-line operation* is provided.

The simplifed call control procedures in § 7 require the stimulus terminal to generate messages based on knowledge of the status of its switchhook and of its alerting mechanism. This requirement may limit the design flexibility for certain terminal types such as multi-line terminals. This Appendix shows example modifications to the procedures which will permit multiple line operation without requiring the terminal to keep track of terminal states.

1. Call establishment at originating exchange

Procedures as described in § 7.1 apply.

2. Call establishment at the destination exchange

The procedures of § 7.2 apply with the following exception : the network interprets the CONNECT message based on its knowledge of current terminal status. In cases in which the "line" selected by the user is different than the line the network has instructed the terminal to alert, the CONNECT message is interpreted as a request for service (SETUP) and the originating call procedures are followed. An example case in which these procedures apply is shown in Figure Appendix 1/Q.930.

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* A multi-line terminal is a terminal which terminates on a single access facility but which has the ability to originate or terminate calls from or to multiple ISDN addresses which may also appear at other access facilities.

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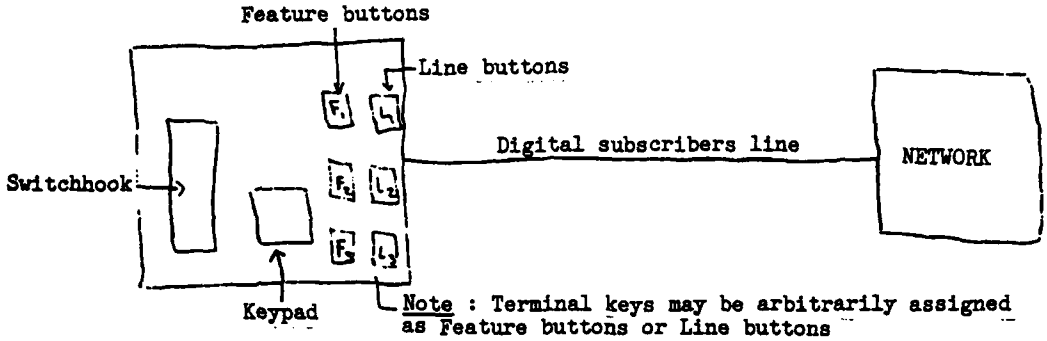
Multi-line terminal



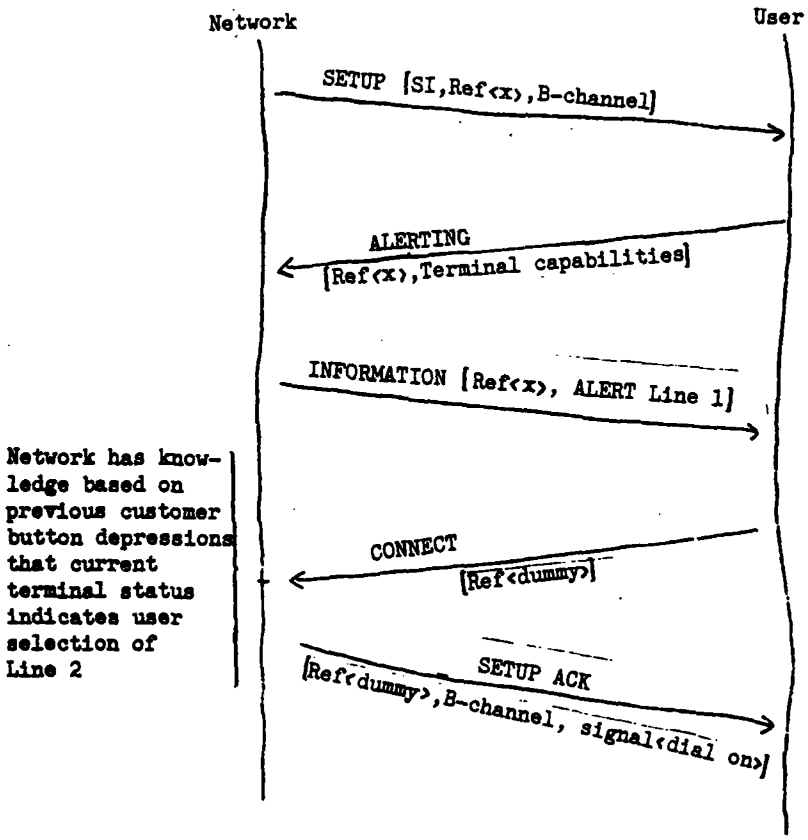


FIGURE Appendix 1/Q.930

Example procedure for multi-line terminal

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